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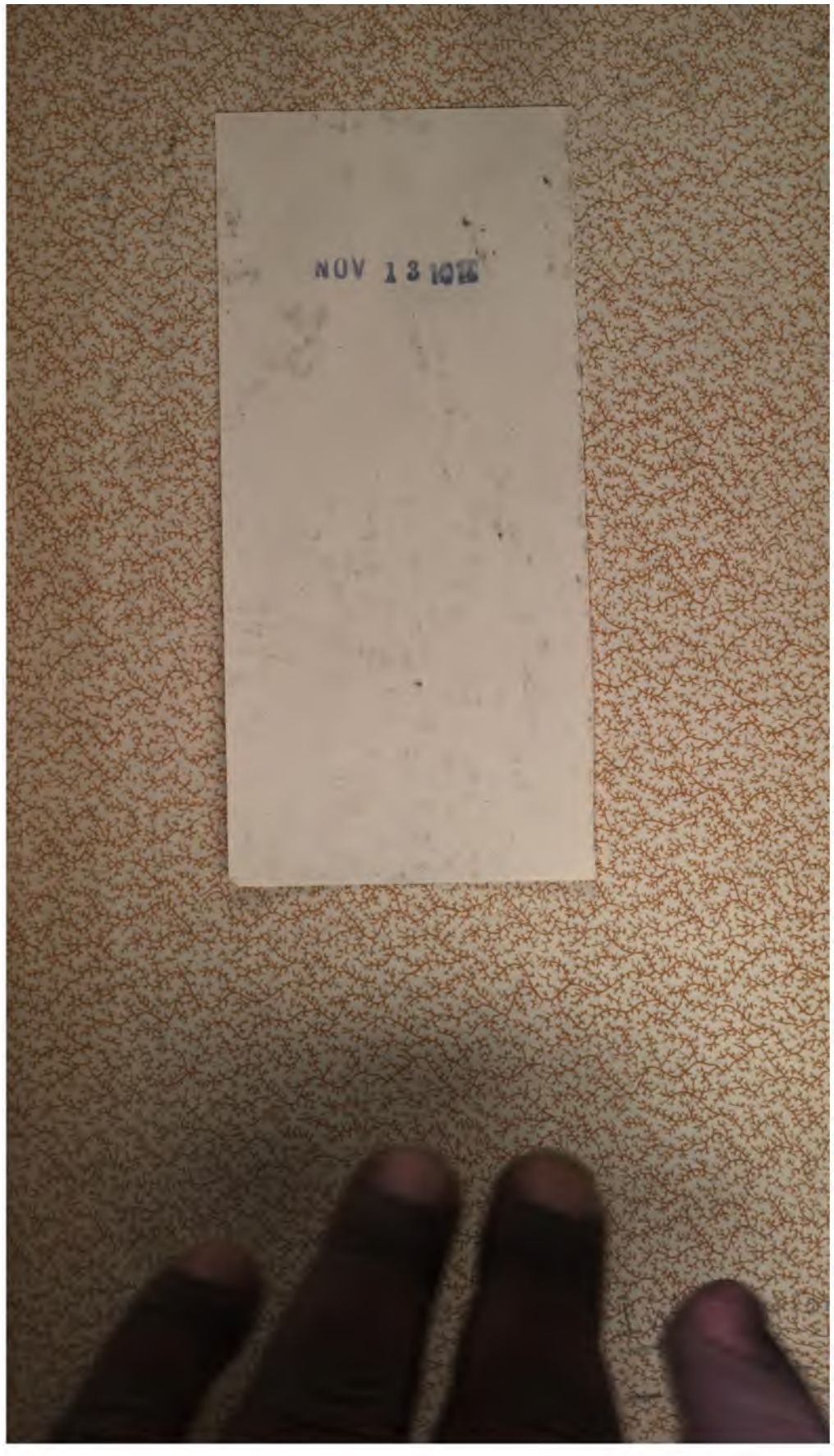
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ПЗВЧУВА
МЗВГІС
МЕЛАОВК

I

THE LISBON HARBOUR

(Porto de Lisboa)

1 album (n^er^ 1) with 9 photographic views: *Aurora,* boat for the conveyance of sand — Steam dredging machine — Floating discharger — Construction of Caes (quay) dos Soldados — Lifting of a pillar-coffer-dam — Between the outport and the Santos dock — Foundation of the great lock-gate — Mole of the outport — Covering of the Alcantara canal.

1 printed description.

6 drawings: General plan of the river Tagus and its margins, embracing the portion of water front comprised between Beato and the Algés stream, with designation of the works proposed by the Commission appointed by ordinance of March 16, 1883 — General plan of improvements of the Lisbon harbour (1st section) according to the project of engineers srs. J. J. de Mattos and A. F. de Loureiro — Longitudinal profiles — Transverse profiles — Types of quay wall, according to the project — Types definitively adopted.

The **Tagus**, one of the finest rivers in Europe, affords to navigation, in its magnificent estuary, the most advanced port of the old Continent on the Atlantic sea-board.

The Portuguese Government imposed therefore on itself, although at the cost of an enormous outlay, the task of endowing this natural sea-port with all the requisite improvements, and has accordingly undertaken the works, in the general plan of which are embraced four great sections.

1st and main section — on the right margin and in front of **Lisbon,** between Caes (quay) dos Soldados and the small canal of Alcantara, length 5:400 meters. It has for object the port, properly speaking, and comprises in a general way the quay line available for the use of vessels, the docks, the filling up and leveling of grounds, the workyards and hydraulic apparatus of the port, the river street and the extension of the Eastern and Northern railway, till it effects its junction with the Western line and with the Cascaes branch-line at Alcantara.

Section the 2nd — below the preceeding, from the Alcantara canal to the tower of Belem, length 3:550 meters. It comprises the rectification of the water front and its revetment with stone pavement in talus, affording room for docks of minor importance.

Section the 3rd — up stream, from Caes dos Soldados to Beato, length 2:400 meters. It embraces the ajusting of that quay to the river bank at Beato, and the gaining over the river of the areas contiguous to the Eastern and Northern railway station and to an already most important industrial quarter.

Finally, section the 4th — on the opposite side of the river, extending from the point of Cacilhas to as far as Trafaria, length 8:000 meters. Its purpose is the rectification of the water line, and the establishment of a marginal road.

It was considered advisable to postpone the arrangements pertaining to the two last sections to a more fitting opportunity.

The works of the 2nd section committed to the Royal Company of Portuguese railways, and to the execution of which the same Company was bound, in return for grants from the Government, are being pushed on with the greatest expedition, having been entrusted by contract to M. *H. Hersent,* the

well known partner of Couvreux in the entreprise of enlargement of Antwerp's harbour.

The works of the 1st section, a much more important undertaking, entrusted likewise to the contractor H. Hersent, are also in full course of execution, being at present, and not long since, under the direct management of the State.

This section includes more especially:

a) The outport, height of water, $8^{m},5$, area $9^{hect.},40$.

b) Below, and in connection with the outport by means of the lock-gate, the Alcantara dock, where vessels can constantly float; height of water 9,15 in mean high tide, area $14^{hect.},30$, giving access to three graving docks, of which only two are being constructed for the present.

c) Above the outport, a tide basin at Santos, height of water 6 meters below the hydrographical zero, area $15^{hect.},93$.

d) Opposite the Naval Arsenal, the dock exclusively devoted to the service of this establishment, area $3^{hect.},12$.

e) Close and above the Custom-house, the dock destined to its special use, area $1^{hect.},50$.

f) In front of Terreiro do Trigo (corn-market), the dock for the vessels engaged in the grain business, area $1^{hect.},50$.

The most interesting and most important part of the works is that concerning the foundation of the quay walls.

The depth of water varies to the limit of 16 meters below the hydrographical zero, and the mud and silt in a state of more or less fluidity, which constitute the bottom, present themselves in thick deposits at depths, which reach 30 meters, on firm ground of varied composition, basalt or limestone, this last alternating more or less with clay, coarse sand and gravel.

The foundations of the walls are constituted by pillars of rectangular section ($8^{m} \times 4^{m}$), perpendicular to the quay line, 10

meters apart, and driven into firm ground by means of compressed air. On the heads of these pillars and reaching from one to another, rest vaulted cap-pieces, laid 2 meters below the hydrographical zero, by means of coffer-dams constituted by great water-tight iron caissons.

Upon these pillars, thus braced by the cap-pieces, are raised the quay walls to the height of 6 meters above the hydrographical zero.

The foundations are carried to the maximum depth of 16 meters, and rest on firm bottom, if found, or otherwise, on a bank of stone-packing shot down to 20 meters into the mud by the help of dredges, the stone imparting to the mud a certain firmness and suffising to give at such depth stability to the ground.

The caissons serving for the pneumatic foundation of the pillars are of rectangular section, and composed of two parts: the under one, fixed, corresponding to the work-chamber and with the approximate height of 3 meters; the upper one, movable and variable in height, according to the depth of the foundations, being drawn up, after the work has been completed, with the help of compressed air, which allows of the unscrewing of the inferior joint, and of the powerful hoisting engines the constructors have at their disposal.

The 4th, 5th and 6th photographs contained in the album give a perfect idea of these operations.

Photograph n^{er} 7 represents the construction of the lock belonging to the wet dock, founded according to the Antwerp system, and more especially the gateway, which is 25 meters wide, by means of a transverse caisson of rectangular section with the dimensions of $39^{m} \times 9^{m}$, the sill of the dock going down to the depth of $8^{m},5$.

Another interesting part of the works is the filling up of the areas gained on the Tagus.

Up stream and down stream, on the river line and on the adjacent slopes, great side-cuttings have been opened, from which material has been taken. This material is afterwards transported to the site of the quays, in wagons drawn by locomotive engines or pushed by hand, either directly from the excavation or by water conveyance and transfer by means of dredges.

What is however more worthy of notice is the dredging in the bed of the river, and the successive dischargements of sand to great distances, merely by means of movable conduits and the help of a constant jet of water.

In these operations play an important part, as multipliers of work, the following types of engines:

The *Aurora* (photograph n^{er} 1), a steam boat, furnished with an engine simultaneously utilized as a propeller and for sucking up the mud and sand. Length 40 meters, maximum width 8^{m},5, depth 4 meters; burden 250 cubic meters; time of loading between 20′ and 30′.

The *Bucket-dredge* (photograph n^{er} 2), moved by steam; it can dredge about 800 cubic meters per day at the maximum depth of 12 to 20 meters. Length of the vessel 31^{m},8, width 6^{m},8, depth 2^{m},4.

But above all others, the *Floating discharging machine* (photograph n^{er} 3) deserves special attention. It is supported on two large barges kept 6^{m},3 apart, and connected by means of an iron framing, the dimensions of each being 27^{m},4 × 4^{m},8 × 2^{m},5. Upon one of these barges is mounted the steam-motor for the chain of buckets, and on the other the pump and the engine for raising the water to establish the continual current in the discharging conduit or tube.

With this conduit merely suspended, and by shortning or extending it to the maximum length of 50 meters, by the addition of separate parts on shore and without any other appara-

tus on the site that is to be filled up, the sand is spread around and rising little by little, though constantly, forms a true *cône de dejection,* extremely flattened and more and more wide, the water taking to itself the task of making the terreplein, and of bringing it nearly to the required level.

Besides the floating property, several important dependencies have been established on shore, either in the form of side-cuttings, for the purpose we have spoken of above, or of quarries for the extraction of building material.

At 2:900 meters above Caes dos Soldados was made the great cutting of Marvilla, and on a line perpendicular to the workyards of the port and corresponding to the line of division of the 1st and 2nd sections, about 3 kilometers up the Alcantara valley, have been worked on a very large scale the quarries of Monsanto and that of Cardim, served by the Western railway. At 5 kilometers below the tower of Belem has been worked likewise the quarry of Caxias.

For the more rapid development of the works, has most undoubtedly contributed the complete and special plant, with which the contractor M. Hersent has furnished the workyards, for the repair and keeping in working order of which he has established at Alcantara the necessary sheds and workshops.

We will just mention the principal engines and other property used, to give an idea of the resources of the workyards:

Four *Auroras;*
Three bucket-dredges;
One floating discharging machine;
Two movable discharging machines;
Two sand-suckers;
Nineteen iron skutes or barges;
Thirteen pocket-mud barges;
Twenty floating pontons;

Eighteen diverse boats;
One steam reservoir skute;
Three floating from 6 to 45-ton derrick-cranes;
Two floating steam hoisters;
One floating steam pile-driver;
Seven floating workshops;
One rock boring machine;
Twelve steam tugs.

The works belonging to the 1st section of the Lisbon harbour improvements are being carried out according to the plan of engineers srs. *J. J. de Mattos* and *A. F. de Loureiro,* with the modifications of system and process of construction proposed by the contractor M. Hersent.

Those of section the 2nd are executed according to the plan presented by the Royal Company of Portuguese railways, who have charge of these works, and are the grantees of the marginal railway.

The contractor M. Hersent intrusted the execution of the works to *M. A. Maury,* the engineer who had so successfully supervised the building in Portugal of bridge *Luiz I*[1] over the Douro in front of Oporto, and who had taken a share in the contract for the works of Funchal harbour in the Island of Madeira[2].

On the part of Government, the works were from the first under the immediate direction of engineer sr. *J. V. Mendes Guerreiro,* reporter of the Commission appointed on the 16th March, 1883, to study the improvements of the Lisbon harbour, of which he has been ever since a stanch advocate; being succeeded by the actual director, engineer sr. *A. F. de Lourei-*

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[1] See album n^{er} 10 — *Luiz I* bridge.
[2] See album n^{er} 22 — Funchal harbour.

ro, whose competence in hydrographical matters has been established many years since by studies and labours, which had especially for field of action the Mondego river basin and the harbour of Figueira. Such labours have been fully described in numerous memoirs of his own, published from the years 1874 to 1881 in the *Revista de Obras Publicas e Minas,* which the Society of Portuguese Civil Engineers (Associação dos engenheiros civis portuguezes) forwards to the Chicago International Exposition.

On the part of the Royal Company the works of construction of section the 2nd were under the direction of sr. *A. de Vasconcellos Porto,* captain of engineers.

II

THE LEIXÕES HARBOUR

(Porto de Leixões)

1 album (nº 2) with 39 photographic views: Leixões harbour and the small towns of Mattosinhos and Leça — *Titan* sinking an artificial block — *Titan* discharging loose rubble stone — Platform for blocks on the Northern mole or breakwater — Engine carrying a block to the front (Northern mole) — Platform area for the manufacture of blocks — Stone mason's workyard of the Northern mole — Workshop for the repairing of materiel (outside view) — Bridge 60 meters in length over the river Leça, for the communication of the workyards — Bottom of caisson of the Northern mole-head — Northern mole — Twenty-five-ton derrick for the inside port — Rocks of Leixões — The same — The same — Seward advancement of the Northern mole — Traverser for change of line in the block's-yard — Workshops for repairs (inside view) — Transport of sand; bridge for the service of the works — Mole head caissons; workshops — Progress of works — Caisson for the Northern mole head (inside view) — Fitting up of the caisson — Twenty-five-ton derrick lowering an artificial block at the mole for the inside port — Southern mole — Fifty-ton-screw-jack-wain for lifting and conveying artificial blocks — Stone mason's workyard; Southern mole — Progress of the Southern mole — The same; *Titan* discharging rubble stone — The same; arrival of train carrying stone — Quarries of San Gens; upper level — The same; cutting for advancement — The same; general view — The same; office, work-shops and stores — The same; upper level — The same; service ways — The same; passage of a train at the weighing machine — The same; train descending from the upper level by the 50 m/m gradient.

1 atlas (nº 3) containing: Specification of the contract — Descriptive memoir (manuscript) — Phototype panoramatic view of the harbour after its completion — Official hydrographic plan with the principal elements of the harbour — Hydrographical plan published by the daily newspaper *Commercio do Porto* — Longitudinal profiles and type profiles of the moles — Details of construction of the mole-heads.

From *Vigo Bay* to the *Estuary of the Tagus*, that is, in the long stretch of coast lying between 42° 10′ and 38° 40′ of

North latitude, no safe refuge was afforded to navigation, so frequently harassed in this part of the sea-board by violent storms.

Nevertheless, on a part of this coast there stood an important commercial mart — **the city of Oporto** — on the north bank and close to the mouth of the **Douro**, a river whose torrential system aggravated the almost perennial agitation of the sea and the tortuousness of its channel, to such a pitch, as to render the port inaccessible for about sixty days in the year.

Shipwrecks were there of frequent occurrence, some being attended with the most distressing incidents. Repeated representations had been addressed by the community to the executive and to the legislature, in order that the State should provide suitable remedy to such an evil, which threatened to ruin the trade of Oporto, burthening it with exorbitant freights, rendering uncertain and perilous the entrance and departure of vessels, causing, in short, the annhilation from one moment to another of lives and property.

Most able engineers, both native and foreign, such as *Espregueira, Rennie, Freebody* and *Abernethy,* had been consulted and had tendered their plans and views on the subject, but such action had remained without sequence.

It was only after *Sir John Coode's* arrival in Portugal, to give his advice on the matter, and after lengthy discussions, the presentation of this engineer's project gave rise to, and in which took a prominent part the director of the works for the improvement of the Douro bar, engineer *Nogueira Soares,* that the plan of constructing an artificial harbour north of the mouth of the said river, opposite Leça and Mattosinhos, received its sanction by royal decree, dated the 26th June, 1883.

The range of rocks, which appears above the surface, in the open sea, in a reef running parallel to the coast, afforded a

most eligible point of support for the head of one of the moles or breakwaters, the name of Leixões harbour having been derived from these rocks.

On the 23rd of January, 1884, the respective department invited proposals for the construction of the said harbour, the basis for licitation being 4.500:000$000 reis (£ 1.000:000), and on the 16th February of the same year was made the contract for the whole undertaking, the works commencing six months after this date.

The harbour is formed by two breakwaters or moles: the Northern breakwater is 1:579^{m},37 in length, resting on the rocks of Leixões, the length of the Southern one being 1:145^{m},25. The former advancing 150 meters beyond the other, there remains between the two mole heads a free passage 220 meters wide.

The area enclosed measures about 95 hectares, the area having a depth of water equal to or above 8 meters being of 40 hectares.

The moles of the type adopted in English ports with as much of upright face as possible and recommended by Sir John Coode were replaced in the construction by those of Marseille's type, proposed by engineer Espregueira and modified by General Nogueira Soares, with great slopes and a base of stone packing or enrockment with quarry blocks of different sizes.

Upon this enrockment was raised the sheltering wall, built of rubble stone set with mortar and hewn stone facings, 9^{m},8 in height, with seaward slope of $^{1}/_{10}$ and the thickness of 5^{m},4 at the base.

Both the base and the upper structure of the mole are protected on the outside by artificial blocks, formed mostly of hydraulic rubble work, some being of hydraulic concrete, measuring about 20 cubic meters each, with the maximum weight of 50 tons.

The natural blocks of the basement were grouped into three different sets: 1st 2-ton, 2nd 8-ton and 3rd 10-ton blocks and upwards.

The mole heads are of circular form and built on the so called upright system, measuring 20 meters in diameter.

The laying of the foundations of the North and of the South mole heads was attempted by means of enormous iron caissons, similar in shape, and filled with rubble stone bedded in mortar, laid dry-shod, the caisson having been previously cleared of water by means of a powerful centrifugal pump.

This system, however, was only successful with respect to the Southern mole head, where the surroundings were more favourable, advantage being taken in the first place of the elevation of the sea bottom in the form of a large rock, brought up to the required formation level by means of concrete in bags, and secondly, of the diminished agitation of the waters, due to the shelter afforded already by the other breakwater.

Regarding the Northern mole head, the difficulties encountered and the accidents supervenient on the sinking of the caissons were so serious, that the method was abondoned, and the basement, after the levelling of the sea bottom, had been effected by means of dredging, divers with helmets and concrete in bags, was formed by artificial blocks laid horizontally in successive courses, without the interposition of mortar.

The foundations of the Southern mole head were carried down 10 meters below the hydrographical zero, and those of the Northern one to 15 meters below the said datum.

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In fact, the quarries of San Gens, situated in the suburb to the north of Oporto and connected with the workyards on the sea side, from the very beginning were a precious find of infinite advantage to the development of the works.

They supplied excellent granite, excessively abundant and of so good a quality, that it has served and is prefered as hewn stone for the buildings of the city. The supply was such, that of itself alone it would have been adequate to the demand, and was never exhausted; add to this, the favourable working conditions of the quarries, situated on a hillock perfectly accessible all around for working purposes, and at moderate distance from the works. Such were the advantages the quarries of San Gens afforded to the contractors.

These quarries, and the quarry-stone yards are most rightly represented in the album by numerous photographs, which give a very good idea of their importance and of their excellent working arrangements.

In the second place — *the Titans.*

These huge cranes, constructed at Fives Lille's Iron works, obeyed so nicely with their 40 meters arm to the will of man, as if they were the most simple contrivance.

With their movementse, ither of translation or of rotation, they went on carrying the moles seawards, with a firmness only comparable to the enormity of their bulk, lowering the artificial block or emptying the wagons of the rough stones, at the precise point, and with as much ease as exactness.

Braving the fury of the sea, they went on steadily ahead, and if at times the wave undermined their foundations, it was only a passing hindrance, for very soon levelled again and established on their proper base, these true Titans never [illegible] less were they ever shaken during the course of

[illegible] nt part played by these gigantic engines in

this construction, is perfectly represented in the major part of the photographs contained in the album[1].

Besides stone and *Titans* there is another important factor: *the weather.*

Winter succeeded to winter, but never did the severity of the season prevent the construction of the breakwaters from advancing. There were, it is true, good instances of storms in these latitudes. We have seen of a moment forty-five-ton blocks raised up, like pebbles, from the talus of the northern sheltering wall, and placed lengthwise in a row on the platform, some crushed, other intact or simply broken at the edges. In short, if the foul weather at one time or another caused the works to slaken, it never interrupted them for any considerable period.

During one of the last campaigns, there was no hope of reaching before winter the foremost rock or *Leixão grande*, a site it was convenient to get at, not to allow the enrockment to remain loose at the point more deep and more sea beaten; the season nevertheless inspired boldness, and it was with a real frenzy that in midwinter the breakwater was pushed seaward with impunity and attained at last the desired mark.

The only damages worth mentioning were those experienced at the conclusion of the works, after the moles were completed, and when the consequences thereof could not be so harmful as during the course of the construction. These damages, however, were most considerable at the Northern mole, the *Titan* belonging to it remaining besides most seriously injured.

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[1] The complete descriptive notice and the justificative calculations of the Leixões *Titan* were published in the *Encyclopédie des travaux publics* of Lechalas — *Travaux maritimes* by F. Laroche. Paris, 1891.

We may regard likewise as favourable elements:

— the excellent quality of the other materials besides stone; the cement obtained from Boulogne-sur-Mer, with the well know brand of Demarle-Lonquety & C^{ie}, deserving special mention;

— the well appointed plant of the contractors, who had at their disposal, besides the two Titans, twenty-seven from 1 to 25-ton derricks, seven locomotive engines, a large number of wagons and workshops completely equiped;

— the unity and the intelligence of the management, whose guiding rule in respect to the technical personnel was to have it limited in number, efficient and well paid;

— finally, the competency of the supervision, repres ented by a director, a specialist with respect to the Douro bar and likewise to the harbour works.

Elements so favourable, as these, would necessarily produce corresponding results, and so they did; for during the eight years that the contract lasted, there was no other accident of serious character worth mentioning, unless the one relative to the foundation of the Northern mole head, and even that cannot be put down as a real disaster, being rather a mishap, involving, it is true, a heavy loss.

What remains to be done is to connect the Leixões harbour with the commercial quarter of the city, with the river side and with the railway system of the country.

The communication by means of a canal was set aside, because of the great expense und uncertainty, not dispensing besides the connection by rail.

The design of the railway has, as will be hereafter seen, been laid out by the Government engineers, as the extension of a branch-line of the Minho and Douro railway, and its construction, not yet commenced, is to be effected by the *Oporto docks and Peninsular Railways Company* (Companhia das docas do Porto

e caminhos de ferro peninsulares), who hold the concession for the working of Leixões harbour.

The Leixões harbour works were carried out on the system of general contract, firstly by Messrs. *Daudernie and Duparchy,* and subsequently by Messrs. *Duparchy and Bartissol,* who succeeded to the former on M. *Daudernie's* decease, which occurred in America, when he was going to undertake some works in the Isthmus of Panama.

The works were, from the beginning till nearly to their close, under the direction of engineer *M. L. Wiriot*, who had likewise conducted the operations of the Oporto water supply, and they were finished under the charge of engineer *Vimont,* now deceased.

The officer charged with the supervision in behalf of Government was General *A. J. Nogueira Soares*, engineer-in-chief of the works for the improvement of the Douro bar.

This most distinguished engineer, whose recent loss we most sincerely deplore, left his name for ever attached to this remarkable enterprise, supervising with superior ability and untiring industry its design and execution, discussing all questions connected therewith with admirable tenacity, he himself making the tests of cements and mortars; in short, passing the last years of his life at the workyards of Leixões.

In the collection of the *Revista de Obras Publicas e Minas* will be found inserted from the year 1871 to 1893 his varied and copious reports, full of facts and ideas, real monographs on the works of the Douro bar and harbour of Leixões [1].

All documents relating to Leixões harbour sent now to Chicago were acquired thanks to the action and solicitude of this worthy functionary.

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[1] See n.ers 13, 41, 42, 44, 51, 52, 53, 111, 148, 150, 152, 154, 156, 191 213, 227, 239, 251, 253, 265 and 268.

III

THE MINHOA ND THE DOURO RAILWAYS

(Caminhos de ferro do Minho e Douro)

Albuns n^er^ 4 and n^er^ 5

Starting point of the lines — **Oporto**, station common to the railway system worked by *The Royal Company of Portuguese Railways*, which serves the second city in the Kingdom.

Length of lines:

The Minho line	130	kilometers
The Custom-house branch-line	4	»
The San Bento branch-line (in course of construction)	3	»
The Braga branch-line	15	»
The Douro line	192	»
Total	344	»

Constructed and worked by the State, who owns them, these railways are the continuation to the north of the Douro of the so called line — do Norte, which, at Ermezinde, distant 9 kilometers from Oporto, divides itself into two branches, one going

northward through the province of Minho, passes at Valença to the Spanish province of Galliza, the other running eastwardly by the Douro valley and across the province of Traz-os-Montes, forms the connection, at Barca d'Alva, with the line, which follows in Spain the route to Salamanca.

The first operations for the construction of these railways commenced in June 1872, coincidently with those of the last portion of the Northern railway, where the difficulty in the passage of the river Douro was surmounted by means of bridge «Maria Pia» [1]. Such operations may be regarded as the beginning of the second period of railways in Portugal.

Government, in place of leaving to companies the administration and management of these lines, took the business into its own hands; instead of supervising, the State constructed, opening thus a large field for action to its own engineers.

The construction of the Minho and Douro railways was of real benefit to the most populous provinces of the Kingdom, putting them in easy communication with their center, the city of Oporto, whose warehouses and stores receive the famous wines known all over the world.

Custom-house branch-line — Recently constructed it puts in communication the Oporto main station, located in its eastern suburb, with the river side, gaining the difference of level of 60 meters in about 4 kilometers, most of which along the steep rocks of the hill side, through them by means of a great tunnel, and underneath the streets of the commercial quarter.

San Bento branch-line — In course of construction, will serve to connect the said station with the heart of the city, reaching it by means of another tunnel, called *Ave-Maria tunnel*, whose

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[1] See album n^{er} 8 — *Maria Pia* bridge.

outlet is trifurcate to afford place to the central station lines of way.

General technical conditions of the road:

Width of way — 1^m,67.

Limit of gradients — 0^m,015 per meter, exceptionally carried to 0^m,016 on the Douro line and to 0^m,020 on the Custom-house branch-line.

Minimum limit of the radius of curves — 350 meters, exceptionally carried to 300 meters on the Minho railway, carried often to 250 meters on the Douro railway and once to 200 meters on the Custom-house branch-line.

Limit of interval of curve and counter-curve — 100 meters.

Width of platform of formation level — 5^m,30;

Width of platform for ballasting — 3^m,30 (Minho), 3^m,60 (Douro);

Width of side drains at the mouth — 0^m,65.

Tunnels: *width* between the abutments — 4^m,75.

Height of axis above the rails — 5^m,50.

Steel rails of 30 kilograms weight per meter and of 8 meters standard length, connected together by means of fish-plates, also of steel, and of four fish-bolts adapted to a longitudinal groove; bolting of rails to the sleepers by means of cramps, of woodscrews at some places, and always when on metallic superstructures.

Strength of materials in the metallic superstructures regulated according to French Department of Public Works circular of the 9th July, 1877.

THE MINHO RAILWAY

1 album (n^er 4) with 22 photographic views: Oporto station — The same — Ermezinde station — Leça bridge — Ave bridge — Nine station — Braga station — Cávado bridge — Tamel station — Durães viaduct — Neiva bridge — Lima bridge — The same — Vianna station — The same — Ancora bridge — Affife bridge — Areiosa bridge — Coura bridge — Valença station — International bridge over the Minho — The same.

Prolonged into Spain, this line connects the city of Oporto with the Vigo and Coruña sea-ports, enabling tourists to visit the most attractive portion of the Peninsula.

After the junction at Ermezinde of the Douro line, it is joined at Trofa by the meter-gauge railway, leading by the valley of the river Ave to Guimarães, and to the thermal watering-place of Vizella, this last being owned and worked for the length of 34 kilometers by *The Guimarães Railway Company* (Companhia do caminho de ferro de Guimarães).

At the following station it is joined likewise by the narrow-gauge line (0^m,90 wide), which starting from Oporto by the sea-side in the direction of Povoa de Varzim, an important place for fisheries and a sea-bathing station, runs inland to Famalicão, a station of the Minho line, ending there after a course of 57 kilometers. This line, constructed and worked by *The Oporto, Povoa and Famalicão Railway Company* (Companhia do caminho de ferro do Porto á Povoa e Famalicão), is owned by the said Company.

From the next station of Nine, the main line detaches a branch of its own to Braga, in the direction of the picturesque sanctuary of Bom Jesus do Monte, a place of general resort for tourists, which is served by an automatic inclined plane 220 meters in length, leading up a height of 116 meters by means of gradients with the maximum slope of $0^{m},45$ per meter.

On reaching Vianna and Caminha the line touches two small sea-ports, the first at the mouth of the river Lima and the other at the mouth of the Minho.

The general direction of this railway from north to south, according more or less to the trend of the coast, rendered inevitable the crossing of the water-lines emptying into the sea, and determined therefore the execution of most remarkable constructive works, which are all represented in the album.

Bridge over the Leça — Built of stone, of one single full-centered arch of 16 meters span and 18 meters height.

Bridge over the Ave — Metallic, two spans of 30 meters each, poised on end-abutments and pillars of stone, and formed of discontinued bowstring girders of Schwedler's system.

Bridge over the Cávado — Metallic, three spans, two lateral of 41 meters each and a central one of 48 meters, supported on stone abutments and cylindrical pillars, $2^{m},20$ in diameter, covered with plates of wrought iron, filled with hydraulic concrete, and founded on rock by means of wooden caissons without bottom and immersed concrete. Height 20 meters. Straight continuous lattice-work girders with large interstices.

Bridge over the Neiva — Metallic, of one single span of 30 meters. Straight lattice-work girders with large interstices. Height 14 meters.

Bridge over the Lima — The most important constructive work of the whole line. It measures, including the marginal viaducts, 733 meters of total length.

Metallic, divided into ten spans, two at the extremities of 47m,5 and the intermediate ones of 58m,5. Piers of stone founded, as well as the south end-abutment, on the compressed air principle, at depths ranging from 20 to 23 meters beneath low-water mark.

It has upper and lower platforms, the lower one for the railway, and the upper one for the common road.

The marginal viaducts are divided into small spans of 10 meters each, resting on cast-iron pillars. They slope on both sides and constitute the approches of the road, which outside the pier-abutments leaves off running over the railway, following thus a lateral course. Upon the river bank, on Vianna's side, the very same pavement carrying the railway continues on viaduct, side by side with the roadway, in order to leave the quay underneath free, so that there are at this point three pavements, one for the quay and the other two for the railway and the common road.

The girders of the main portion of the bridge, 7m,5 in height, are straight, continuous and of lattice-work, with large interstices and without uprights.

Areiosa and Affife bridges — Of stone, having both a depressed arch of 14 meters span.

Bridge over the Ancora — Metallic, of one single span of 30 meters, differing, however, from the Neiva bridge in having the railway on the lower part of structure.

Bridge over the Coura, a tributary stream of the Minho, close its mouth — Metallic, with three spans, one central of 60 meters and two marginal of 50 meters each, and with under flooring. Piers of stone.

The foundations, established on the principle of compressed air, were sunk to the maximum depth of 15 meters in oozy ground; maximum, which at the *Mira bridge*, situated further up and of one single span of 20 meters, was carried down to

20 meters by the same process, in a similar bottom, if not worse.

International bridge over the Minho — Double-floored, the upper one for the railroad and the one beneath for the common roadway.

Metallic, with five spans, two at the extremities of 60 meters, and the intermediate of 66 meters each, besides two smaller spans at the approches, of 15 meters each, to give access to the road. Height of girders, $6^{m},6$.

Total length of the bridge, counting with the posterior abutments, $399^{m},2$. Height above low-water mark, $24^{m},6$. Weight of iron-work, $1{:}775^{ton},602$.

Piers of stone resting on caissons sunk pneumatically to depths ranging from 16 meters for the first pier to 22 meters for the fourth. Length of caissons, $9^{m},7$; width, 4 meters.

Girders in the main portion of bridge, straight, continuous, of lattice-work and quadruple interstices, and with uprights ever 5 meters. Width of structure between the parapets of the railway, 6 meters; 5 meters on the under platform, at the level of which, outside the girders, and on either side, there is a foot-walk, $1^{m},5$ wide.

The macadam pavement of the under floor was lately substituted by wooden parallelopipeds, resting on the primitive rectangular incurvate plates.

The flooring of the railroad is thoroughly covered with striated plates.

The assemblage of buildings on the opposite side of the river, seen in the photograph, is Tuy, a Spanish town, the seat of a bishop, the cathedral surpassing in height all the other edifices.

This international bridge was erected at the joint cost of Spain and Portugal, the part built of stone having been constructed directly by the administration of each of the States,

and the metallic part by Portuguese administration, the disbursement being afterwards debited in equal shares to the two conterminous countries.

There is a complete monograph relating to the construction of this bridge, which forms part of the contributions of *The Society of Portuguese Civil Engineers* to the Chicago Exposition (see *Revista de Obras Publicas e Minas,* vol. XVII, 1886).

There is only on the Minho line one single viaduct, it is however remarkable for its importance and beauty; it is known by the name of *Durrães viaduct.* By its aspect, in which are blended at one time lightness and solidity, it calls to mind the Comelles viaduct in France.

It is all built of stone, with sixteen full-centered arches of 9 meters span each; minimum height, 22 meters; total length, 180 meters. Constructed in a straight line, but with a slope of $0^{m},014$, it derives, however, one of its greatest beauties from the lucky manner in which the difference of level from arch to arch is compensated.

Tunnels. — Six in number, the most important being the *Tamel tunnel,* 980 meters in length, its maximum depth being of 52 meters, in order to gain the watershed of the Cávado and Neiva hydrographic basins.

Next comes the *Caminha tunnel,* 410 meters in length, pierced to avoid the spur on the left bank of the river Minho, close to its mouth.

Stations. — Twenty-three in number, among which deserve special mention: *Oporto* station, as the most important; *Vianna,* remarkable for its architecture; *Valença,* on the frontier; *Braga,* terminus of the branch-line and the highest point attained by the railway. The principal buildings of these stations are represented in the album.

THE DOURO RAILWAY

1 album (n° 5) with 40 photographic views : Cabeda viaduct — Ferreira bridge — Cette station — Paredes station — Bridge over the Sousa — Cahide station — Villa Meã viaduct — Villa Meã station — Marco station — Tamega bridge — Juncal station and Encambalados tunnel — Quebradas viaduct — Palla viaduct — The same, lower portion — Ovil viaducts — Viaducts of Palla and of Ovil — Mosteirô station — Valley of the Douro and Laranjal viaduct — Aregos station — The Douro valley — Ermida station, Zezere and Teixeira bridges — Bridge over the Zezere — Bridge over the Teixeira — Loureiro and Murta tunnels — Pass of Murta — Sermenha viaduct — Moledo station — Jogueiros bridge — Regua station and tunnel — Corgo viaduct — Tunnel of Pedra Caldeira — Covellinhas station — Pinhão bridge and Pinhão station — Tua viaduct — Valleira tunnel — Bridge over the Douro (left bank) — Bridge over the Douro (right bank) — Teja tunnels — Barca d'Alva station — International bridge over the Agueda.

Leaving Ermezinde, the railway continues to get away from the Douro, crossing a region of pleasing aspect, as that of Minho, but, after a run of about 50 kilometers, it begins to draw near that river, and, having reached Mosteirô station, it plunges into the rugged gorge, at the bottom of which the Douro flows confined, the line pursuing then the route by the river side to the frontier.

The scenery then changes completely, the horizon becoming circumscribed. The banks of the river display their picturesque and shelving sides, covered more or less with vegetation, and the current assuming the features of a real torrent, in-

terrupted frequently by water-falls, dashes on across the time-worn and rugged bluffs.

At Regua, the line reaches the center of the old vine-growing region of the Douro. To this point converge several roads and subsquently will likewise converge the line coming from Villa-Real to Regua, laid out already by the Government engineers in the direction of Villa Franca das Naves, where it will effect the junction with the Beira-Alta railway.

The passage across the wine-country has a peculiar character, imparted to it by the view of the terraces, which rise one above another on both sides of the river, as may be observed in many photographs of the album, and by the decreasing ruggedness of the banks and of the bed of the Douro, formed of slaty strata, which succeed to and are intercalated with the granites.

From Foz-Tua proceeds the narrow gauge railroad, which follows the route to the center of the province by Mirandella, its most remarkable constructive works being represented in two of the albuns of the present collection [1].

A little further on passed Cachão da Valleira, a point of most difficult access and for a long time the term of fluvial navigation, the line crosses to the opposite side, on which it pursues its course to the frontier.

To Pocinho converge the draught-lines of two railways laid out by the Government engineers, one of narrow gauge, on the left bank, crossing the line of Regua to Villa Franca das Naves in the direction of Vizeu; the other, of standard gauge, traversing the iron ore deposits of Moncorvo and those of marble and alabaster of Vimioso, by Miranda, straight to Zamora in Spain.

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[1] See album n^{er} 6 — Mirandella railway, and album n^{er} 9 — Railway bridges.

At Barca d'Alva the Douro line ends, crossing the Agueda river, a confluent of the Douro, near its mouth. It reaches, however, through the neighbouring kingdom as far as Boadilla, where its extension is merged into the railway, which, continuing the Beira Alta line, follows the route to Salamanca, this last getting in its turn confounded at Medina del Campo with the Northern railway of Spain.

To reach the pass of Cabeda between Ermezinde and Vallongo, to pass the water lines flowing in a perpendicular direction to the river Douro, and to cross the said river, it became requisite to construct the principal bridges and viaducts in the following order:

Cabeda viaduct — Built entirely of stone, composed of seven full-centered arches of 15 meters span each, laid out in a curve, whose radius is of 500 meters, preserving the maximum inclination of 0,0165 per meter of the line. Maximum height, 30 meters; length, 130 meters.

Bridge over the Ferreira — Metallic, having one single span of 29 meters with abutments pierced each of them by two full-centered arches of 10 meters; it describes a curve, whose radius is of 400 meters. Height, 20 meters.

Bridge over the Sousa — Of stone, having one main arch of 15 meters, and two secondary arches on either side all full-centered.

Villa Meã viaduct — Composed of four metallic spans supported on piers and abutments of stone; central spans of 50 meters each, lateral spans of 40 meters. Maximum height, 25 meters; length, 183 meters.

Tumega viaduct — Composed of five metallic spans, three central of 56 meters and two lateral of 45 meters each, with stone abutments and metallic piers. Maximum height, 56 meters; length, 300 meters.

Quebradas viaduct —With three metallic spans, a central

one of 50 meters and two lateral of 40 meters each, resting on stone abutments and on metallic pillars. Maximum height, 42 meters; length, 160 meters.

Palla viaduct — Four spans, two central of 50 meters each, and two lateral spans of 40 meters. Abutments of stone and metallic pillars. Through the basement of the deepest pillar und under an arch 7 meters span, flows the Palla stream. Maximum height, 52 meters; length, 200 meters.

Ovil viaduct, spaning the torrent of this name — It is built entirely of stone and with a curve of 300 meters radius, having five full-centered arches. Maximum height, 38 meters.

Laranjal viaduct -- Entirely of stone, having six arches of 15 meters span. Maximum height, 24 meters; length, 131 meters.

Sermenha viaduct — Formed of four main spans and two secondary ones, resting on pillars and abutments of stone. Width of main spans, 50 and 40 meters respectively; width of the secondary spans 20 meters, to give passage to the common road. Maximum height, 28 meters; length, 300 meters.

Corgo viaduct — Metallic, with three spans, the central one of 50 meters, the lateral spans of 40 meters each, resting on abutments and pillars of stone. Maximum height, 24 meters; length, 150 meters.

Pinhão viaduct — Metallic, oblique, with one single span of 39 meters; length, 119 meters.

Roncão viaduct — With one single metallic span, central, of 20 meters, and two full-centered stone arches on each side of 9 meters span; length, 85 meters; height, 20 meters.

Tua viaduct — Metallic, with six spans, the central being 30 meters in length and the marginal 24 meters, pillars and abutments also of stone. Length, 182 meters; height, 22 meters.

Riba-Longa viaduct — With one single span of 20 meters

and two full-centered arches, 10 meters in diameter at the abutments. Length, 57 meters; height, 16 meters.

Bridge over the Douro — Metallic, oblique, of seven spans, the central of 57 meters and the marginal of 46 meters. Abutments and oblique pillars of stone. Maximum height, 37 meters; maximum height of the pillars, 28 meters; minimum thickness of the same, $2^{m},5$. Length, 412 meters.

Arnozello viaduct — Metallic, four spans of 32 and 40 meters. Abutments and pillars of stone. Length, 170 meters; height, 32 meters.

Vargellas viaduct — Metallic, three spans of 20 and 25 meters. Abutments and pillars of stone. Length, 80 meters; height, 23 meters.

Teja viaduct (over a torrent) — Built entirely of stone, with four full-centered arches of 15 meters in diameter. Length, 90 meters; height, 24 meters.

Murça viaduct — Mixed system, three spans of 32 and 40 meters, and next seven full-centered stone arches of 10 meters in diameter. Length, 206 meters; height, 34 meters.

Gonçalo Joannes, Nedo and Pocinho viaducts — Metallic, three spans of 28 and 35 meters. Abutments and pillars of stone. Length, 104 meters; heights, 27, 30 and 18 meters.

Canivaes viaduct. — Of stone, three full-centered arches, 15 meters in diameter. Length, 64 meters; height, 21 meters.

Coa, Aguiar and Gricha viaducts — Metallic, three spans of 28—35, 32—40, and 28—35 meters. Abutments and pillars of stone. Lengths, 103, 120 and 109 meters; heights 26, 24 and 20 meters.

Agueda international bridge—Metallic, askew-bridge of five spans, those at the center of 40 meters and those at the sides of 32 meters, the common road passing underneath, through the abutment on the side of Spain, span of 12 meters. Maximum height, 29 meters; length, $223^{m},68$.

This bridge was entirely built by the Portuguese Government, the expense being shared between the administrations of the two conterminous countries.

There is a complete monograph concerning the construction of this bridge, published in the collection of the *Revista de Obras Publicas e Minas* (vol. XX 1889), which the Society of Portuguese Civil Engineers sends to the Chicago International Exhibition.

The whole of the *constructive works* on the Douro line have been founded on the solid rock, even pillar n.er 5 of the bridge over the Douro, the foundation of which offered the greatest difficulty, was sunk down to a rocky base by means of a metallic caisson without bottom.

The metallic structures are all of straight, continuous, girders with large interstices, and supplied with Hartwich's safety counter-rails.

The tunnels of this line are not as numerous as the viaducts; they make up a total of twenty-three with the aggregate length of 6:915 meters.

Those deserving special mention are:

Tapada tunnel — Length 1:086 meters, at the maximum depth of 100 meters, in order to pass from the hydrographic basin of the Sousa to that of the Tamega river;

Encambalados tunnel — Length, 1:621 meters; the longest tunnel of the two lines, at the maximum depth of 123 meters, to pass from the Tamega to the Douro basin;

Loureiro tunnel — Length, 403 meters;

Valleira tunnel — Length, 711 meters;

Monte-meão tunnel — Length, 750 meters; to traverse the spurs on the banks of the Douro.

The *stations* are twenty-seven in number, the most remarkable being that of *Regua,* of first class, the center of passenger and goods traffic of the two provinces of Traz-os-Montes

and of Beira Alta, serving on one side the town of Villa Real and on the other the town of Lamego; *Pinhão*, also an important station in the wine-growing country, and *Barca d'Alva* on the frontier.

THE CUSTOM-HOUSE BRANCH-LINE

Maximum gradient, $0^m,020$ per meter; minimum radius of junction curves, 200 meters.

The most remarkable work on the Custom-house branch-line is the *Oporto tunnel,* built under the city, at depths ranging from zero to 50 meters and upwards, with gradients mostly of $0^m,016$.

It is 1:258 meters in length: 969 meters being through the solid granitic mass of the elevated quarters of the town, and 289 meters more or less immediately under the pavement and following the alignements of Infante D. Henrique street and of Alfandega street.

Its first portion passes 27 meters below the foundations of the avenue of bridge Luiz I[1]; its second portion, crossing under S. João street, passes between the pavement of this street and the collecting sewer of the city, which was requisite to sink to a lower level.

The Custom-house branch-line, when extended along the river and the sea side, will connect the Custom-house with the artificial harbour of Leixões[2], according to the plan submitted already to Government by its own engineers.

The *metallic superstructures* of the bridges and viaducts on

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[1] See album n^{er} 10 — *Luiz I* bridge.

[2] See album n^{er} 2 and album n^{er} 3 (atlas) — Leixões harbour.

the Minho and Douro railways were supplied by the following firms:

Messrs. *Harkort* (Germany) — Bridges over the Ave and Este rivers (Minho);

Fives-Lille (France) — Bridge over the Coura and the Mira rivers (Minho) and over the Ferreira (Douro);

G. Eiffel (Le Vallois-Perret, near Paris) — Bridges over the Cávado, Neiva, Lima, Ancora (Minho). Viaducts of Villa Meã and Tamega (Douro);

Cail & C^ie (Paris) — Viaducts of the Douro from Quebradas to the Corgo (Douro);

Braine-le-Comte (Belgium) — International bridge over the river Minho; bridge over the Douro; viaducts from Roncão to as far as Arnozello, and from the Coa up to the international bridge over the Agueda (Douro);

Sclessin (Belgium) — Viaducts of Gonçalo Joannes to as far as Pocinho.

The *rolling stock* common to both lines consists of:

Engines	32
Saloon and sleeping-cars	10
First class carriages	24
Second class carriages	24
Composite carriages (1st, 2nd)	7
Third class carriages	60
Composite carriages (2nd, 3rd)	8
Baggage wagons	19
Diverse wagons	449
Total	633

Almost all the locomotives were supplied by Messrs. *Beyer, Peacock & C.°* of Manchester.

These locomotives are of three types:

1st, three axles, of which two are conjugate; diameter of the respective wheels, 1^m,60; cylinders outside and horizontal, diameter 0^m,42, stroke of pistons 0^m,56; distance between the external axles, 3^m,4; total weight in working order, 33:500 kilograms;

2nd, three conjugate axles; diameter of the wheels, 1^m,30; cylinders outside and horizontal, diameter 0^m,46, stroke of pistons 0^m,61; distance between the external axles, 3^m,35; weight, 34:200 kilograms;

3rd, tank-locomotives of Wroxall's type with three axles, of which two conjugate; diameter of the wheels, 1^m,14; cylinders inside and inclined, diameter 0^m,41, stroke of pistons 0^m,56.

Besides these types, there has lately been adopted a supplementary one for the goods traffic of the Custom-house branch: tank-locomotives with three conjugate axles, and one free, posterior, radially mounted; diameter of the wheels, 1^m,20 meter; cylinders outside and horizontal, diameter 0^m,48, stroke of pistons; 0^m,70, maximum pressure in the boiler, 10 atmospheres.

The carriages and wagons were successively furnished by the following firms: *Fives Lille* (France) and Messrs. *Nicaise & Delcuve* (La Louvière, Belgium) and *Morlanwelz* (Belgium).

The *general workshops,* spaciously built, are located close to the Oporto station, and its machinery and tools were furnished by the *Fives Lille* manufactories.

The earth-works, constructive works and other buildings of the Douro and Minho railways were, in general, constructed on

the system of partial contracts or undertakings, successive portions of line being open to traffic from time to time.

The works began on the 9th July, 1872.

First portion open to traffic — Oporto to Braga, 20th May, 1875.

Inauguration of the last portions with the Minho and Agueda international bridges, respectively: on the 25th March, 1886 and on the 8th December, 1887; of the Custom-house branch-line, on the 8th November, 1888 (for goods traffic only).

Directors simultaneously of each line:

Engineer sr. *João J. de Mattos* (for the Minho line).

Engineer sr. *Lourenço de Carvalho* (for the Douro line).

And successively of both lines:

Engineers srs. *Boaventura José Vieira*, *A. C. Justino Teixeira*, *J. Anastacio de Carvalho*, *A. Luciano de Carvalho*.

Engineer in chief of the construction (Minho line), sr. *C. Xavier Cordeiro*.

Actual Director, engineer, sr. *A. C. Justino Teixeira*.

IV

THE MIRANDELLA RAILWAY

(Caminho de ferro de Mirandella)

1 album (nr 6) with 24 photographic views: Prezas viaduct — Prezas tunnel — Prezas tunnel and viaduct — Tralhariz station and Alvella tunnel — Mills of Castanheiro — Amieiro village — Tunnel and viaduct of Fragas-Más — Fragas-Más, Cruz tunnel — Paradella bridge — Pulpito do Diabo (The Devil's pulpit) — Caldas de San Lourenço (thermal waters) — San Lourenço station and baths — San Lourenço station — Cabreira bridge — View of Pedra Longa — Vieiros viaduct and Abreiro bridge or Ponte do Diabo (The Devil's bridge) on the road — Vieiro viaduct — Abreiro bridge (on the road) — Puxa-Preto pass — View of Fragas do Piado — Meirelles bridge and Villa Flor station — Mirandella station — Mirandella — Panoramatic view of Mirandella and environs and of Tua bridge (on the road).

Branch-line of the Douro railway, commencing at kilometer 132. *Meter-gauge* line of way, the width being measured between the inside edges of the rails. Length, $54^{kilom},5$.

Constructed and worked by The Railways National Company *(Companhia Nacional de Caminhos de ferro)*, grantee likewise for 99 years of the Vizeu branch-line of the Beira Alta railroad, with 5,5 per cent interest guaranteed by the State.

Inaugurated on the 29th September, 1887.

The line follows by the valley of the **Tua**, a tributary stream of the Douro, cutting across, in the first 17 kilometers of its course, the granitic rocks, which form on the banks of this river and in the vicinity of the point of confluence abrupt crags, and in its bed repeated falls.

Pursuing its route, the line runs through ground by degrees more open and less rugged, of slaty formation, interrupted here and there by ridges of quartz, which of a sudden confine the bed of the Douro.

Maximum limit of *gradients*, never attained, 0,018 per meter; *minimum limit* of *radius of junction curves,* 150 meters; *limit of intervals of curves and counter-curves,* 50 meters.

Transverse type section of permanent way: $3^m,50$ of platform of formation level; $1^m,90$ of platform for ballasting; *width of side drains in slope*, $0^m,40$ at the mouth.

Tunnels section—Width at the springings $4^m,29$; at the level of the rails, $3^m,90$; height of axis, $5^m,54$.

It was at the first section, the most rugged portion of the line, owing to the precipitous nature of the hill-sides, that the constructive works, such as *bridges, viaducts* and *tunnels,* were more frequent, as shown in the album.

The *sustaining walls* as far as kilometer 20, composed nearly all of stones set up without mortar, are as numerous as the embankments.

With the exception of Frechas bridge, formed of one single depressed, circular and three centered arch of 12 meters span and $4^m,50$ rise, the *bridges* and *viaducts* are mixed structures of iron and stone, with one or two spans having from 15 meters (Meirelles) to 42 meters (Prezas).

Special plates representing these works will be found in album n^{er} 9 («Pontes de caminhos de ferro»).

The *metallic superstructures* are composed of straight lattice-work girders, formed of St Andrew's crosses and of vertica[

uprights, $2^m,60$ apart from each other, leaving free a space $3^m,50$ wide between the parapets. The rails are provided with Hartwich's counter-rails.

The superstructures were supplied by the iron-works of the *Société de Braine-le-Comte* (Belgium).

The *tunnels,* six in number, have lengths, which range between 35 meters (Fragas-Más, 2nd) and 140 meters (kilometer n^{er} 10).

Some of the *sleepers* are of northern pine creosoted, others of oak from the forests of the country, or imported from Spain; dimensions $1^m,80 \times 0^m,12 \times 0^m,24$.

The *rails* of Vignolles type are of steel, weighing 20 kilograms per lineal meter, and of 6 meters standard length.

The mode of connecting the rails together is by means of two fish-plates fastened by four fish-bolts, and that of pinning or bolting the rail to the sleeper by means of wood-screws with the interposition of sole-plates.

The whole railway plant was supplied by the *Bochum Works* (Westphalia).

Rolling stock—Six tank locomotives of one single series and type, with three conjugate axles, 1 meter diameter wheels and a fore axle of smaller diameter, free and supplied with Webb's radial apparatus; distance between extreme axles $4^m,70$; cylinders outside the framing, the diameter of piston being $0^m,350$ with a stroke of $0^m,500$, placed between the fore axle and the one immediately behind. Total length between the buffers, $8^m,984$; total weight, 21 tons.

Constructed at the *Esslingen works* (Wurtemberg).

Saloon carriage	1
First-class carriages	3
Composite carriages (1st, 2nd)	2
Second class carriages	8

Third class carriages	10
Baggage wagons	6
Diverse goods-wagons	44
Total	74

Manufactured at the works of *Société métallurgique de Nivelles* (Belgium).

The Mirandella railway attains at this point the center of the province of Traz-os-Montes, and it is intended it should traverse a mining and forest region of some importance up to Bragança, according to the survey already made for the length of 37^{kilom},499 by the Government engineers.

Director of the Company during the construction, engineer sr. *A. X. de Almeida Pinheiro.*

Engineer-in-chief of the construction, sr. *Moreira da Motta.*

V

THE BEIRA ALTA RAILWAY

(Caminho de ferro da Beira Alta)

1 album (nr 7) with 39 photographic views: Figueira station (sea port) — Alhadas tunnel — Pampilhosa station — Luso station — Varzeas viaduct — Salgueiral tunnel — Milijozo viaduct — Trezoi viaduct — Mortagoa station — Mortagoa valley — Breda viaduct — Criz viaduct — Tunnel of Monte dos Lobos — Coval viaduct — Valley of the Dão river — Dão viaduct — The same — Santa Comba station — Mangualde station — Mourille tunnel — View of Quinta das Barrocas — Mondego valley — Gouveia station — Leganhede viaduct — Fornos bridge — Muchagata bridge — Jejua bridge — Castle of Celorico — Celorico station — Between Pinhel and Guarda — Guarda station — Noemi bridge — Village and old bridge of Cerveira — Fraga bridge — Noemi viaduct — Côa viaduct — Villar Formoso station (on the border).

Length 252 kilometers, between **Figueira da Foz**, a seaport at the mouth of the Mondego river, and **Villar Formoso** on the Spanish frontier, where the line continues in the direction of Salamanca, running from thence to Medina-del-Campo, on the Northern Spanish railway.

Constructed and worked by *The Beira Alta Portuguese Railway Company* (Companhia dos caminhos de ferro portuguezes da Beira Alta) in two sections: one section from Figueira da Foz to Pampilhosa, a railway station common to the line called «do Norte»,

50 kilometers in length, without subvention from the State; and the other from Pampilhosa to the frontier, with the subvention of 23:000$000 réis[1] per kilometer; length 202 kilometers, both section with concession to work the same for 99 years.

Inaugurated on the 3rd August, 1882.

Standard width of way, 1^{m},67. *Maximum* limit of gradients, 0^{m},015 per meter; *minimum* limit of *radius* of curves, 350 meters; *maximum* limit of curve and counter-curve, 100 meters.

The general course followed is that of the Mondego valley, from the right bank of which it deviates to gain at Pampilhosa a higher level, in order better to surmount the Bussaco mountain, where lay the main difficulties of the construction.

From the starting point at Figueira the general profile is in slope, as far as Portella de Villa Franca das Naves, which is the water-shed of the rivers Mondego and Douro. Crossing its declivities, the line continues thenceforward to ascend to Guarda, being the highest point attained, 814 meters above the level of the sea.

At Santa Comba, the center of the important vine-growing region of the Dão, the railway comes into contact with the narrow gauge branch-line of Vizeu, constructed and worked by *The National Railways Company* (Companhia Nacional de Caminhos de ferro) for the length of 49,56 kilometers.

At Villa Franca das Naves will be effected the junction with the Douro line, by means of the railway already laid out by the Government engineers, which will have for starting point the Regua station and will pass by the town of Lamego.

At Guarda station is effected the junction with the Beira Baixa railway, opened to general traffic on the 11th May,

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[1] 1$000 réis is equivalent to 4s 5$^{1}/_{2}$d.

1893, the remainder being constructed according to the grant made to *The Royal Company of Portuguese Railways* (Companhia Real dos caminhos de ferro portuguezes).

Most of the *constructive works* represented in the album, and by far the most important, belong to the Pampilhosa and Santa Comba section, that is, to that portion of the line traversing Serra do Bussaco.

It is there that is situated the Salgueiral tunnel, 1:095 meters in length, and the longest of the line, as well as the Varzeas and Criz viaducts, also the longest, both with eight spans, being respectively 303 and 208 meters in length, and the Dão viaduct, the highest and likewise one of the most extensive.

Nearly at the end of the line is worth remarking the Coa viaduct, with five spans, 207 meters in length.

Total number of *tunnels*, thirteen, measuring altogether 3:823 meters.

Total number of *viaducts*, twelve, aggregate length 1:678 meters.

Large and small or one arched *bridges*, thirty-four; *culverts* and *passages* over and under the railway, thirty.

The width of the *tunnels* at the height of the springings is 5 meters and at the level of the rails, $4^{m},50$. Minimum of height above the rails, $5^{m},50$.

There are only three viaducts exclusively built of stone, the remainder being of iron and stone; the pillars are almost all metallic. The most remarkable viaduct is that of the Dão, as shown in the two plates.

Of bridges and culverts, only three are built of iron and stone, all the others being exclusively of the last material.

The *stations* are twenty-seven in number, two of them, that of Figueira and of Pampilhosa being common to the system of railways owned by *The Royal Company of Portuguese Railways*.

Rails of steel, weighing 30 kilograms per lineal meter, the standard length being 8 meters. They are bolted to the sleepers by means of wood-screws.

The *sleepers* are of pine-wood growing in the country, injected with sulphate of copper, and also of oak imported from Spain.

The *rolling stock* consists of:

Engines	16
First class carriages	16
Second class carriages	18
Composite carriages	6
Third class carriages	40
Baggage wagons	10
Diverse wagons	314
Total	420

There are eight engines of each of the following types:

1st, two conjugate axles, and leading on front wheels free; diameter of the coupled wheels $1^m,65$ and of the free wheels $1^m,12$; framing and distribution inside, cylinders outside, being $0^m,43$ in diameter, with a stroke of $0^m,61$; distributing slide of Allan's system; distance apart of the centers of the extreme axles, $3^m,5$; length between buffers, $8^m,2$; total weight of the engine in working order, 34:500 kilograms;

2d, three conjugate axles, diameter of the wheels $1^m,41$, these engines being able however to receive wheels of $1^m,31$, $1^m,41$ and $1^m,51$ in diameter; framing inside, cylinders and slide valve outside, the cases of the same being placed above, with a slope of 135,25 per meter; diameter of cylinders $0^m,46$, stroke $0^m,64$, distributing slide of Stevenson's system, with crossed bars; distance apart of the centers of the extreme

axles, $3^m,7$; length between buffers, $8^m,68$; weight, 36:000 kilograms.

In the locomotives of either of these types, in order to facilitate the passage in the curved parts of the way, the fore wheels have a lateral swing of 200 $^m/_m$ in the slide of the axle guards, and the guides are furnished with inclined planes to conform the fore axle to the axis of the line.

Carriages and wagons manufactured by: *Société Industrielle Suisse* of Nehausen near Schaffhausen, Messrs. *Dietrich & C.°*, of Neiderbronn, and *Dyle & Bacalan,* of Paris.

Director of the construction, *M. E. Bartissol.*

General contractors for constructive works and earth-works: *M. Duparchy* (for the first part), *M. Daudernie* (for the second part).

General contractor for metallic superstructures of bridges and viaducts, *M. G. Eiffel.*

Present Director of the Company: *Count de Gouveia,* formerly engineer attached to the direction of the construction.

VI

BRIDGE MARIA PIA

(Ponte Maria Pia)

Royal Company of Portuguese Railways

1 album (n^er 8) with 10 photographic views : First phase of the works observed below stream, on the Oporto side — Progress of the works, viewed up stream, on both sides — The same, platform advanced from one and the other bank — The same, advancement from the Oporto side — The same, seen below stream, the whole erection with the arched span suspended on each side — The same, viewed up stream —The same, below stream, the arched span viewed in course of connection — The same seen up stream — The same, joining together of the inferior portion of the arch — Close of the erection, observed below stream.

The erection over the Douro of bridge Maria Pia, as well as the construction of the first portions of the Minho and the Douro railroads, are facts which mark out the commencement of the second period of railways in Portugal.

The Royal Company, which had initiated and set up the first period by constructing the Northern and Eastern lines, had stopped before the impediment offered by the crossing of the Douro in front of Oporto, at a spot, where the banks of that river are more precipitous, the gorge more deep and the current more impetuous.

The building of the last section of the line was being pursued with a large development of works, remarkable constructions were in course of execution, and an extensive circuitous route had been chosen for the passage up stream to Oporto, when the consideration of the technical difficulties in the establishment of the great bridge and of the consequent heavy outlay determined the suspension of operations.

Some years after, in 1872, the financial conditions of the Company being more favourable and the improvements in the art of construction more encouraging, they resolved upon turning back, abandoning the works carried already to a certain point, and to erect the bridge straigthway, close to the city of Oporto.

Accordingly, in 1875 the competition was advertised among the most daring bridge builders, and the resolution adopted of raising an immense metallic structure spanning the river with an arch nearly equal to the largest of the St. Louis bridge over the Mississipi, the largest span of bridge till then erected.

The works commenced about the beginning of 1876, and about the close of the same year they were interrupted in consequence of the heavy winter rains, and finally on the 4th November, 1877, took place the solemn inauguration of that bold construction.

The bridge measures 352^{m},87 in length, being composed:

1stly — Of one single great arch of 160 meters span and 42^{m},6 of average rise, on whose haunches rest two pillars;

2dly — Of a central platform 51^{m},88 in length, forming body with the arch;

3dly — Of a lateral platform, on the south side, of 169^{m},87, divided by metallic pillars in two spans of 28^{m},75 each, resting upon the central arch, and in three spans of 37^{m},37 resting upon the bank;

4thly — Of another lateral platform, on the northern side, of

132^{m},8 divided like the preceding, with exception of one span less on dry ground.

Height of rails above the level of the hydrographic zero, 61^{m},28.

Maximum height of the two pillars resting upon the abutments of the arch, 42^{m},93.

All the stone basements were laid dry-shod, excepting the angle of the abutment of the south bank on the ebb side, the foundations of which were sunk at once by draining in the interval between two tides.

The grand arch of bridge Maria Pia is the most important member of this magnificent structure. Without mentioning the general dimensions, which are truly wonderful, there are three circumstances in its disposition, which impart to it a special character:

1st — Suppression of the spandrils, in consequence of the difficulty of taking into account the variations of temperature and the mobility of the extra loads, in relation to parts that in that portion of the construction would come to 35 meters or 40 meters;

2nd — The inverted crescent-shaped form of the arch, resulting from the necessity of giving to it, by reason of the suppression of the spandrils, the required rigidity to resist of itself to the strain of deformation produced by the unequal distribution of the extra load, and of making the intrados and the extrados converge on the supports in an axis, that should allow freedom of motion and determine well the point of passage of the strain, the arch attaining thus at the crown the extraordinary height of 10 meters, and dwindling down to a pointed termination at the springings;

3rd — The symetric inclination of the planes of the two ribs, resulting from the necessity of giving to the superstructure, by means of a large base, the required resistance to the im-

pulsion of the wind, and from the economic advantage of reducing at the top the width of the structure to the minimum of platform of roadway, hence resulting that at the level of the rails the interval is only of $3^m,95$, and of 15 meters at the level of the springings;

4th — The penetration of the upper portion of the crescent into the lines of girders of the platform, the upper line remaining thus tangent to the extrados, by means of which it was possible to obtain the reduction of the surface exposed to the wind, increase the rise of the arch, and establish more close connection with the superstructure.

The erection of the arch represented the main difficulty of the undertaking; it was, however, carried out with the best success, by the adoption of a method at one time simple and bold.

The extraordinary height of the structure, the deepness of the water below and the impetuosity of the current, precluded the idea of employing scaffolding of any kind.

The points of support were therefore sought and found on each side of the portion already erected of the same superstructure, that is, the first parts of the arch were secured by the axis to the pier abutment, and stayed on shore by means of wooden props; the metallic pillar was raised upon the pier abutment, and finally the platform carried out beyond the pier, as far as it could safely be done without support.

With such points of support, and with the help of two steel-wire cables, first made two-fold and afterwards four-fold, firmly braced above the pier to the full frame of the main girders, this part being in its turn fastened by its extremities on the land-side by means of strong iron tension-rods fixed to the abutment (on the south bank), or to the rock (on the north bank), the different frame pieces of the crescent were successively and symetrically put into place, being hoisted up from

the barges, till the two key pieces of the intrados touched each other.

The key of the intrados being in place, the arch of course assumed its definite position, as soon as the temperature of the metal reached the suitable degree (15°).

Total weight of the iron work required for the bridge, 1:450 tons, 750 tons being for the arch and 700 tons for platform and pillars.

Cubature of the portion built of stone, 4:000 cubic meters.

Published in the collection of the *Revista de Obras Publicas e Minas*, will be found papers concerning this important undertaking — See vol. 7, 1876; on the proofs, see vol. 9, 1878.

Designers of the project, and general contractors, Messrs. *G. Eiffel & C^ie^;* collaborators in the project, *T. Seyrig* and *H. de Dion;* acting engineers, *E. Nouguier* and *M. Angevère.*

Director of the Company, sr. *M. Affonso d'Espregueira;* engineer-in-Chief of the construction, sr. *P. I. Lopes.*

It was still during the second period and immediately after the construction and opening of the last section of the Northern Railway, that the Royal Company constructed the Portuguese portion of the line from Lisbon by Caceres to Madrid, branching out from the Eastern line at Torre das Vargens, portion which the said Company has rendered worthy of notice by maintaining through it the circulation of the international express train, called *Sud-Express*, a line having extensive curves of 300 meters of minimum radius and gradients of 0^m^,018.

As a proof of this kind of work is noteworthy the case of the train, which on the 18th November of last year conveyed the Royal Family, on their return journey from Spain, and that reached the frontier three hours behind time.

This train drawn by two locomotives, and composed of twelve vehicles, among which were saloon carriages weighing 30 tons each, making altogether 208 tons, recovered in Portugal, that is in 262 kilometers, most of the time lost, by going over, of a run, the tortuous Caceres branch-line, at an average speed of 50 kilometers per hour.

The Royal Company initiated likewise the third period of railway progress in Portugal by building the Western line, its principal constructive work being the bridge over the Mondego river [1], and signalized this period by considerable improvements such as:

The construction of the Metropolitan line and the Circuit line of Lisbon, affording thus to all trains easy access to the heart of the capital, and, as a point of arrival and departure, the station whose façade is represented in one of the photographic views of album n^{er} 13.

The establishment of a second line on the portions of way common to the Eastern and Northern and to the Western and Cintra lines.

The adaptation of Saxby and Farmer's system to the lines of the Lisbon central station, and of the *block system* to the Metropolitan and Circuit lines.

The illumination by electric light of the principal stations.

The replacement, in the constructive works, of the primitive metallic platforms by others more in keeping with the increased weight of the new locomotives.

The erection from the foundations of a new stone pillared bridge over the river Tagus, in place of the old one, whose tubular pillars were rent or split in several places [2].

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[1] See album n^{er} 9 — Lares bridge.

[2] See album n^{o} 9 — Constancia bridge.

Finally, the Royal Company has recently opened to traffic the last section of the Beira Baixa line, its third parallel, which branching out from the Eastern line at Abrantes, crosses the Tagus[1], and by the frontier goes up to establish at Guarda a third point of contact with the Beira Alta railway, by following the course of the Tagus, ascending the Castello Branco table-land and surmounting Serra da Gardunha with the help of numerous constructive works, being remarkable for its height the San Pedro viaduct.

The total length of the Royal Company's Railway system is 1:069 kilometers, divided as follows:

	Kilm.
The Metropolitan and Circuit railways	13
The Eastern railway and Caceres branch line	347
The Northern railway	231
The Western and Cintra railways	243
The Cascaes railway	23
The Beira Baixa railway	212
Total	1:069

In the following table will be found, indicated by their most characteristic features, the six principal types of locomotive engine used in this railway system:

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[1] See album ner 9 — Abrantes bridge.

Designation	Tank locomotives		Locomotives with separate tenders					
	1st type	2nd type	3rd or bogie type	4th type (compound) with bogies		5th type		6th type
				Wheels $d = 1^m,8$	Wheels $d = 2^m,0$	110th series	150th series	
Number of axles .... free....	–	1	2	2	2	–	–	–
Number of axles .... coupled	3	3	2	2	2	3	3	4
Distance between the coupled axles	$3^m,500$	$3^m,340$	$2^m,590$	$2^m,591$	$2^m,591$	$3^m,430$	$3^m,600$	$4^m,130$
Distance between the extreme axles.....	$3^m,500$	$5^m,931$	$6^m,320$	$6^m,731$	$6^m,731$	$3^m,430$	$3^m,600$	$4^m,130$
Diameter of the wheels free....	–	$1^m,080$	bogie $0^m,900$	bogie $1^m,105$	bogie $1^m,105$	–	–	–
Diameter of the wheels coupled	$1^m,400$	$1^m,410$	$1^m,860$	$1^m,841$	$2^m,000$	$1^m,300$	$1^m,420$	$1^m,300$
Diameter of cylinders.....	$0^m,420$	$0^m,483$	$0^m,432$	0,470/0,686	0,489/0,711	$0^m,450$	$0^m,480$	$0^m,500$
Stroke of pistons.....	$0^m,630$	$0^m,660$	$0^m,610$	$0^m,660$	$0^m,660$	$0^m,650$	$0^m,640$	$0^m,660$
Disposition of cylinders	Outside	Outside	Inside	Outside	Outside	Outside	Outside	Outside
Disposition of distribution ..	Outside	Inside	Inside	Inside	Inside	Inside	Outside	Outside
Weight in working order	$36^{kg},000$	$58^{kg},672$	$42^{kg},800$	$43^{kg},915$	$44^{kg},957$	$38^{kg},000$	$43^{kg},240$	$48^{kg},048$
Weight in tenders	–	–	$23^{kg},900$	$26^{kg},111$	$30^{kg},124$	$23^{kg},000$	$23^{kg},900$	$23^{kg},900$

The rolling stock consist of:

Engines	149
Saloons, sleeping cars, etc	21
First class carriages	103
Second class carriages	164
Composite carriages (1st and 2nd class)	27
Third class carriages	248
Composite carriages (2nd and 3rd class)	10
Composite carriages (1st, 2nd, and 3rd class)	10
Baggage wagons	96
Diverse wagons	1:903
Total	2:731

The last supplies of locomotives were made by the following firms:

Beyer, Peacock & C°, of Manchester; *Sächsische Maschinenfabrik,* of Chemnitz; *John Cockerill,* of Seraing; *Société Alsacienne de Constructions Mécaniques,* of Mulhouse-Grafenstaden, and *Maschinenfabrik* of Esslingen;

The supply of carriages, by the firms: *Chevalier Cheilus,* of Paris, *Société de St. Denis,* of Paris, *Desouches, David & C^ie^*, of Pantin (Paris); *Dietrich & C^ie^*, of Niederbronn (Alsace); *Société Industrielle Suisse*, of Neuhausen.

And the supply of wagons, by the following: *Société de Morlanwelz* (Belgium); *Nicaise & Delcuve*, of La Louvière (Belgium); *Société Dyle & Bacalan,* of Paris; *La Métallurgique,* of Nivelles (Belgium).

RAILWAY BRIDGES

(Pontes de caminhos de ferro)

1 album (nº 9) with 27 photographic views: International bridge over the Minho river (Minho railway) — International bridge over the Agueda (Douro railway)— Prezas viaduct (Mirandella railway) — Fragas-Más viaduct (the same) — Paradella bridge (the same) — Cabreira viaduct (the same) — Vieiro bridge (the same) — Meirelles bridge (the same) — Portella bridge, over the Mondego (Arganil railway) — Miranda do Corvo bridge, over the Eça (the same) — Ceira bridge (the same)— Corrolo bridge (the same)— Lares bridge, over the Mondego (Western railway) — New bridge of Constancia, over the Tagus (Eastern railway) — Abrantes bridge, over the Tagus (Beira Baixa railway) — Oeiras viaduct (Cascaes line) — Quinta Nova bridge (Southern railway) — Mira bridge (the same) — Magra bridge (the same) — Mouratos bridge (the same) — «Trinta metros» bridge (the same) — Bridges A, B, C (the same) — Odelouca bridge (the same).

The bridges of Portuguese railways form naturally *three groups,* corresponding to the periods which we have already indicated in the account given of these railways.

The *first group* comprises the bridges of the Northern and Eastern railways, distinguished by small spans (30 meters of maximum width), tubular pillars, superstructures of Kennard's system, discontinuous and dissymetric main girders with the form of an inverted U, the inferior ends merely formed by vertical plates, the cross-girders in general being placed under the main girders and fastened with screw bolts.

The *second group* comprises the bridges of the Minho and Douro railways, of the 5th section of the Northern line, of the Beira Alta railway, of the Caceres embranchment and of the Mirandella railway, marked by the tendency to the reduction of the great masses of masonry in the abutments, by broader spans, by pillars of stone or of metallic framework, by superstructures of various types, generally of continuous, straight, symetric and lattice-work girders put together and run over from one of the abutments.

The *third group* includes the bridges belonging to the last sections of the Douro line, to the Southern railway, to the Cascaes line, to the Arganil and Beira Baixa railways, the whole of them connected by a trait of resemblance, uniform in type, the superstructures having continuous main girders, of lattice-work and double T, maintaining the great spans to the maximum of 60 meters.

In the first group are the following bridges and viaducts of the Northern line:

Seiça viaduct (5 spans of 31 meters);

Bridges over the Mondego (9 spans of 31 meters);

Esgueira viaduct (8 spans of 30 meters);

Vouga bridge (14 spans of 19 meters).

And of the Eastern line:

Caia bridge (3 spans of 20 meters);

and not long since were:

Asseca bridge (5 spans of 30 meters);

Alviella bridge (3 spans of 22 meters);

Tagus bridge (16 spans of 30 meters);

lately replaced by new ones.

The tubular pillars of these bridges, $1^{m},8$ and $0^{m},9$ in diameter, had their foundations sunk to the maximum depth of 16 meters, and were charged by means of rails. The under excavation was made by divers, the pillars being afterwards

filled with hydraulic concrete and covered with metallic heads.

The superstructures, formed at the main girders by bars of rectangular sections and in the form of |___|, and at the cross girders and longitudinal bearers by double T bars, are constituted by metal work of such excellent quality, that it has allowed them to support a working of coefficient far superior to the 6 kilograms per square millimeter of the regulation.

In the second group are comprised:

On the Minho and Douro railways the *bridges over the rivers Ave, Cávado and Lima,* of the Minho line, and the numerous series of *viaducts of the Douro line* up to Pinhão, bridges and viaducts to which we have made reference in the portion of this catalogue relating to these railways.

On the Mirandella railway the *Prezas and Fragas-Más viaducts,* and the bridges we have mentioned in detail when treating of the special album of this railway, which are represented, as well as the viaducts, in the album we are now describing.

On the Beira Alta railway the *Varzeas, Criz, Dão* and *Coa viaducts,* from among many other important constructive works, that the special album of this railway represents in numerous plates.

On the lines of the Royal Company of Portuguese Railways, in the Caceres branch-line, the following viaduct and bridges:

Niza viaduct (2 spans of 25 and 1 of 29 meters);

Sever bridge (3 spans of 20 meters);

and above all these remarkable constructive works, in the 5th section of the Northern line, *bridge Maria Pia*, constituting the special subject of album n^{er} 8.

In the third group:

On the Minho and Douro railways, belonging to the Minho line, the *international bridge* over the river of this same name,

represented in the album of the respective line, and when in course of construction represented in the album we are now treating of.

On the Douro line the *bridge over the river Douro*, the viaducts of the last sections beyond the Pinhão, and the *international bridge over the river Agueda,* comprised in the album of this line.

On the Arganil railway, a line of normal width, extension of the branch line of Coimbra, and still in course of construction:

Portella bridge, over the Mondego (2 spans of $48^{m},36$ and 2 of $52^{m},39$), immediately above the bridge of the same name on the royal road n^{er} 12 of Coimbra to Celorico, as represented in plate n^{er} 14 of the present album.

Foundation of the masonry piers by compressed air; girders straight and continuous; flooring above.

Height of rails above low-water mark, 18 meters.

On the lines of the Royal Company of Portuguese Railways the following bridges and viaducts:

Lares bridge, over the Mondego, represented in plate n^{er} 15 (11 spans of 50 meters);

Soure bridge (3 spans of 40 meters);

Founded both by compressed air. Flooring below.

Oeiras viaduct (2 spans of 38 meters and 1 of 49 meters);

Flooring at mid-height of the girders;

the first bridge on the Western line and the second on its branch at Alfarellos; the viaduct (with double line of way) in the Cascaes branch, and on the Beira Baixa line the more remarkable bridges and viaducts, which on account of their number are mentioned in the following table:

Names	Number of spans	Lenghts of the spans — Meters		Total length of the superstructures
		End spans	Intermediate spans	
Abrantes bridge, over the Tagus..	7	48	60	427,7
Abrantes bridge, approaches.....	2	15	–	
Ribeira Fria viaduct...	2	25	–	51,6
Eiras viaduct.....	3	25	30	80,6
Cannas viaduct.....	3	24	30	78,6
Cova Fundeira viaduct.....	3	20	25	65,5
Freixo viaduct.....	2	30	–	61,6
Meirinho viaduct.....	2	30	–	61,6
Peral viaduct.....	3	40	50	130,7
Caimbas viaduct.....	3	32	40	104,7
Ocreza viaduct	3	32	40	104,7
Cereja viaduct.....	3	20	25	65,6
Alamo viaduct.....	1	–	40	41,84
Assucar viaduct	1	–	40	41,84
Gonzalo viaduct	3	20	25	65,6
Nossa Senhora viaduct	1	–	40	41,84
San Pedro viaduct.....	3	50	60	160,7
Cerejal viaduct	3	32	40	104,7
Rodeios viaduct	2	30	–	61,6
Enxames viaduct.....	1	–	40	41,84
Carneiros viaduct.....	1	–	40	41,84
Alcaide viaduct.	1	-	40	41,84
Meimôa bridge	1	60	–	62,0
Zezere (first) bridge.....	3	32	40	126,3
Zezere, approaches..... .	1	20	–	
Carpinteira viaduct	1	50	–	51,9
Corge viaduct.....	4	40	48	192,9
Corge viaduct, approaches	2	15	–	
Zezere (second) bridge	3	37	45	120,7
Maçainhas viaduct.....	3	40	50	130,7
Gogos viaduct.....	3	40	50	130,7
Benavente viaduct.....	3	24	30	76,6
Penha Barroca viaduct	3	37	45	120,7

The *San Pedro viaduct*, whose maximum height reaches 65 meters, is the loftiest structure in the Portuguese railroads.

To this group belong also the bridges that the said Company has rebuilt in the Eastern line, such as:

Asseca bridge, Alviella bridge and *bridge over the Tagus* near Constancia.

The *Asseca bridge,* of most difficult foundation, was replaced by another at the same site and without the smallest interruption for railway trains, although situated in the portion of line of most active traffic.

The new bridge has three spans, one of 59 meters, one of 44 and a small one of 10 meters, this variety of spans being due to the difficulties supervening on the laying of the foundations.

The *Alviella bridge* was rebuilt below the old one, according to a variant in the primitive plan of the line at that point, the new bridge being of a single span of 60 meters.

The *new bridge over the Tagus* is, after bridge Maria Pia, the most important constructive work of the Royal Company's railway system, being represented in photograph n^{er} 16 of the present album. It has 8 spans, 1 of 45 meters, 7 of 52 meters, besides a small one for access of 15 meters on the left bank; it has an oblique disposition to 62° 43′; the maximum height of the pillars is 11^{m},78 above low-water, that of the main girders being of 6 meters.

The line of way on this bridge is established nearly at mid-height of the main girders on lattice cross girders with the disposition of St. Andrew's crosses, in the whole height between the sleepers and the lower part of the structure. The uprights are likewise of lattice-work in perpendicular direction to the line.

The Asseca, Alviella and Tagus new bridges were founded on the principle of compressed air, at depths, which reached

in the last one the maximum depth of 18^{m},64, the pillars of the same being descended to the firm rock.

The Asseca and Alviella bridges were totally rebuilt to carry double line, including the metallic superstructures. On the Tagus bridge, whose masonry has been built with the dimensions to carry the two tracks, the laying of the second flooring has been deferred to a future time.

To the third group of railway bridges belong still the bridges and viaducts constructed by the State in the extension of the Southern railway, and represented at the end of the album, namely:

Quinta Nova bridge — 2 spans of 32 meters and 2 of 40 meters; 2 metallic pillars of 15^{m},84 and 1 of 12^{m},85. Length of flooring 144^{m},6;

Mira bridge — 2 spans of 35 meters. Length of flooring 72 meters;

Magra bridge — 2 extreme spans, independent, of 20 meters; 2 intermediate, continuous, of 30 meters. Length of flooring 106^{m},2;

Mouratos bridge — 3 continuous spans, 2 of 24^{m},6 and 1 of 30 meters; 2 metallic pillars of 18^{m},37. Length of flooring 79^{m},8;

«*Trinta metros*» *bridge* — Length of flooring, of one single span, 32 meters;

Bridges A, B, C — Floorings identical, divided into 3 continuos spans, 2 of 20 meters and 1 of 25 meters. Metallic pillars of 10^{m},2 in the two first and of 7^{m},4 in the third. Lengths 65^{m},5.

Notwithstanding their small height, which should have led to the rejection of the system of construction followed for the pillars, if the conditions had been regular, the pillars for these three viaducts were made of iron in consequence of the absolute want of good stone in the district.

Odelouca bridge — 5 continuous spans, 2 of 14 meters and 3 of 17 meters. Length 79^{m},73.

The Southern railway system, in the extension of which to the province of Algarve are situated these last bridges, is owned and worked by the State.

It is composed of the following lines:

	Kilom.
Southern line — Barreiro terminus (on the left margin of the Tagus) and Faro, a sea-port on the coast of Algarve	341
South-Eastern line — Beja to Pias in the direction of the frontier	42
Branch-line of Setubal (a sea-port)	13
Extremoz branch-line, by Evora	78
Total	474

With the exception of the bridge over the Guadiana, formed by 8 spans of 30 meters each, and of the bridges above mentioned, the constructive works of this description in the Southern railway system, which is laid over a region in general not very mountainous, are of small importance.

The tunnels are only two in number, situated in the Southern line for the crossing of Serra de Monchique:

Valdisca tunnel, length 696^{m},67.

Horta tunnel, length 99^{m},48.

The rolling stock consists of:

Locomotives	44
Saloon carriages	7
First class carriages	21

Second class carriages	25
Third class carriages	59
Composite carriages	10
Post-office cars	6
Baggage wagons	42
Diverse wagons	747
Total	961

The types of locomotive-engines are defined in the following table:

Designations	Locomotives					
	For express trains	Mixed trains	Mixed trains	Tank-locomotives	Goods trains	Goods trains
Number of axles { free	3	1	–	–	–	–
Number of axles { coupled	–	2	3	3	3	3
Distance between the extreme axles	4m,515	4m,420	3m,429	3m,352	4m,622	3m,429
Distance between the extreme coupled axles	–	2m,210	1m,814	1m,828	2m,311	1m,968
Diameter of the wheels { free	Central 2m,158 1m,190 Extreme	1m,190	–	–	–	–
Diameter of the wheels { coupled	–	1m,558	1m,546	1m,416	1m,403	1m,330
Diameter of cylinders	0m,410	0m,406	0m,460	0m,412	0m,457	0m,450
Stroke of pistons	0m,585	0m,559	0m,650	0m,610	0m,610	0m,650
Position of the cylinders	Inside	Inside	Outside	Outside	Inside	Outside
Distribution of steam	Inside	Inside	Inside	Inside	Inside	Inside
Weight in working order	31:700 kilog.	27:100 kilog.	40:100 kilog.	36:500 kilog.	28:500 kilog.	37:800 kilog.

The locomotive were manufactured by the following firms: *Beyer, Peacock & Co*, of Manchester; *Sharpe Steward*, of Manchester; *Société Alsacienne de Constructions Mécaniques*, of Mulhouse-Grafenstaden; *Hannoversche Maschinen A. G. Linden*.

The carriages by: *The Metropolitan Railway Company*, of

Birmingham; *Van Der Zypen & Charlier,* of Cologne; *La Métallurgique,* of Nivelles (Belgium), and the 2nd and 3rd class carriages in the administration's workshops, at Barreiro.

The wagons by: *Dyle & Bacalan,* of Paris; *La Métallurgique,* of Nivelles (Belgium); *Société de Morlanwelz,* of Belgium, and in the administration's workshops.

VII

BRIDGE LUIZ I, AT OPORTO

(Ponte Luiz I, no Porto)

1 album (nᵉʳ 10) with 20 photographic views: Commencement of erection of the arch, observed from Oporto, up stream — The same, from Gaia, down stream — Second phase, the same — The same, another point of view — The same from Oporto, down stream, bridge Maria Pia seen in the back ground — Third phase, observed from Gaia, down stream — Portion of the workyard, on the Oporto side, close to the suspension bridge — Fourth phase, seen up stream — The same — The same — The same — Fifth phase, connecting together of the arch — The same, observed from Oporto, up stream — The same, laying on of the girder; the same, down stream — The same — The same — The same, with the suspension bridge, seen from Oporto, up stream — Sixth phase, placing of the lower flooring, the same — The same, seen down stream — Close of the erection, general view, up stream.

The construction over the Douro river of the great arch of bridge Maria Pia for the passage of the Northern railway, close to Oporto, reawaked in that city the old aspiration of possessing a bridge that should join the heigher part of its eastern quarter with the opposite suburb of Villá Nova de Gaia.

The opportunity had never been more favourable, because the old suspension bridge[1], which served the lower quarter, had reached the limit of time assigned to it.

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[1] See album nᵉʳ 12 — Road Bridges.

Government, therefore, acquiescing to the earnest request of the citizens of Oporto, advertised, in August, 1880, the opening of a public competition for the construction of a great double-floored bridge at 20 meters distance from the suspension bridge, under the chief following conditions:

1st — That the lower platform should be a single span of 172 meters, resting on the rocky banks of the river and without any intermediate support;

2nd — That the upper platform should be $48^{m},3$ above the lower platform, and composed of two parts; one being the bridge, properly so called, superposed to the river bed, and the other formed by the marginal viaducts, the one on the Oporto side with two forced points of attachment, the first imposed by the disposition of the rock and the second by the interval left by the buildings of a street forming stair-way;.

3rd — That the width of the lower platform should be of 8 meters, $5^{m},6$ for roadway and $1^{m},2$ for each of the side-walks, and of the upper platform 6 meters, 4 meters being for roadway and 1 meter for each of the side-walks. Total length of the bridge between the abutments of the upper platform $392^{m},5$;

4th — That the dimensions of the iron work should be calculated to resist the testing extra load of 2:000 kilograms per square meter of platform uniformely distributed, the coefficient of the working remaining within the limit of 6 kilograms per square millimeter for plate or wrought iron subject to compression or extension, exception made for the diagonals of the lattice-work, whose coefficient should be of 5 kilograms.

The dimensions of the iron work not belonging to the main girders, namely of the cross-girders, should be calculated to resist to the simultaneous passage of a couple of four wheeled vehicles with the weight of 3:000 kilograms on each wheel and with 3 meters interval between the axis.

For the resistance of the platform to the wind, accept the

hypothesis of the equivalence of the same to an horizontal pressure of 150 kilograms per square meter in the case of the bridge under a passing load, and of 270 kilograms without such load;

5th — That the term for the execution of the whole undertaking should be of twenty-four months, counting from the date of adjudgment.

Eleven French, Belgian and English firms offered their tenders and with the exception of one, which was not Eiffel's, the whole of them differed from the plan of bridge Maria Pia.

It is worth examining the set of reduced designs contained in one single plate, showing the elevations of all the plans tendered at the competition and published together with the report of the Commission of Government engineers in the *Revista de Obras Publicas e Minas*, vol. 12, 1881, which forms part of the collections sent by the Society of Portuguese Civil Engineers to the Chicago International Exhibition.

Preference was given to one of the two projects presented by the *Société de Construction de Willebroeck*, as satisfying more completely to the conditions and spirit of the respective programme, this project being subscribed by the distinguished French engineer M. *T. Seyrig*, principal coadjutor of M. *G. Eiffel* in the elaboration of the design of bridge Maria Pia.

In respect to the series of prices demanded, this project occupied the ninth place, and amounted to £ 82:000

So that about 1 kilometer below bridge Maria Pia and in sight of this fine edifice, between the steep rugged rocks of the Douro and where the river banks suffer a contraction, was erected with equal boldness a similar structure.

In the same manner as with bridge Maria Pia, the great arch is its most prominent feature, but, contrary to what may be observed in that structure, it increases in height from the crown to the springings, commencing with $7^{m},5$ and ending in

a normal manner with 12 meters, this disposition being imposed by the need of countervailing the ribs at the extremities, without hindering the access to the upper platform.

The ribs are 7 meters apart at the crown and 15 meters at the base, this disposition being similar to that of bridge Maria Pia.

The under parts of the ribs have a pointed end, and rest on two hinges fixed to the abutments; the upper ones, as well as the diagonals and the countervailing pieces of the extrados, end in a frame resting simply against the corresponding abutment.

The abutments, the height of which above the pavement is $15^{m},52$, are built in the form of porticos, and they simultaneously give access to the lower platform and serve as basement to the marginal pillars, which are $28^{m},08$ in height.

The upper platform, the main girders of which are penetrated, as in bridge Maria Pia, by the arch's curve of the extrados and are equidistant $4^{m},40$ from each other, is 5 meters in height, and in a similar way to bridge Maria Pia, is divided, between the main pillars, into five spans, a central one 62 meters in length, confounded in part with the arch; two contiguous, one on each side, both of 23 meters, resting by one end upon the arch and by the other on a pier-trestle raised on the extrados to the height of the haunches, and of two other immediately following of 36 meters, which rest on one side on the pier-trestle and on the other on the pillar.

The said platform is prolonged on either bank: on the Lisbon side by two spans, the immediate one of 44 meters, and the succeeding one of 36 meters, both divided by a metallic pillar; on the Oporto side by three spans, the two first of 49 meters each, and the last one of 37 meters, successively divided by a stone and a metallic pillar.

The lower platform is $3^{m},2$ in height, and besides the support

it finds on the abutments, is hung by four suspending-ties rigid and firmly attached, consisting of two trestles connected by lattice-work horizontal cross-beams and by countervening pieces disposed in the form of St. Andrew's crosses, 36 meters apart at the central and immediate intervals, the marginal intervales of the said suspending-ties being of 33 meters, prolongation of the trestles on the haunches of the arch to the extremities of the platform.

The disposition given to the lower platform in articulated portions, according to the primitive design presented for competition, was rejected in the definitive plan, so that the platform remained perfectly continuous.

The pavement of the lower platform is macadamized; that of the upper one is formed of parallelopipeds of wood laid on a bed of cement.

The operations of erecting the arch were performed in accordance with the method followed in the case of bridge Maria Pia, and effected without the least accident and with the best success.

The inauguration of bridge Luiz I, the total length of which is 442 meters, 392 meters being of metallic platform, took place with due solemnity on the 31st October, 1886.

The engineers intrusted with the construction by the *Société de Willebroeck* were firstly M. *Angevère,* who began the works, but had to leave in consequence of an attack of illness of which he died, and afterwards M. *Maury,* who continued them when scarcely commenced, and carried them out to the end.

Both had been graduated by the Paris Central School of Arts and Manufactures.

Director charged with the supervision in behalf of Government, engineer sr. *J. Macedo Araujo.*

ENTRE-OS-RIOS BRIDGE, OVER THE DOURO

Album (n^{er} 11) with 9 photographic views: Foundation; 1st phase — Foundation of pillar n^{er} 2 — Erection of platform — The same, continuation — The same — Close of the erection — Panorama of the bridge with the platform in course of erection — The same — Panorama of the bridge after its completion.

The **Douro** is one of the largest rivers in the Iberian Peninsula and the second river of Portugal; what gives to it, however, the pre-eminence it enjoys is the torrential nature of its stream.

Its average fall from Zamora, in Spain, is of 1^{m},5 per kilometer. During the great freshets its current reaches at certain points the maximum velocity of 7 meters per second, and the height of its waters 25 meters above low-water mark.

The variations of its flow have been calculated by some to range from 30 to 30:000 cubic meters between low-water and the greatest floods.

Up to 1870 nobody had dared to lay below the frontier the foundations of a bridge's pier in its bed, there being only the suspension bridge[1] opposite Oporto spanning the river, from

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[1] See album n^{er} 12 — Road Bridges.

crag to crag, at a point where the cliffs draw close to each other.

After that, the first attempt, ere long crowned with success, was made at Regua on the upper Douro [1]. Prudence advised, however, when the constructors recognized want of stability in the strata of the subsoil and even after the metallic platform had been ordered, the replacement on the side of the navigable channel of two spans by a large one and by a small span on the bank.

It was only ten years later that the plan of another bridge was carreid out, with piers founded in the bed of the river.

Such is **Entre-os-Rios bridge,** constructed below and near the confluence of the river Tamega, a little way above the rocks known as Pedras de Linhares, the first water-fall and a reduced example of the rapids and falls, which are so frequent up stream.

At this spot the valley expands, and its sides disclose most beautiful landscapes. The northern avenue of the bridge midway up the hill affords to the beholder an extensive and continuous gallery or veranda, from which he can enjoy a goodly prospect.

To the left stretches a wide sandy beach, uncovered during the greatest part of the year, but that during the winter and the spring freshets is frequently flooded, the water usually rising 10 meters above low-water mark, there being record of some cases when it attained the maximum height of 22 meters.

Entre-os-Rios bridge measures 330 meters between the extremities of the abutments, in 300 of which is comprised the metallic platform.

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[1] See album n^{er} 12 — Road Bridges.

This platform has five principal spans of 50 meters each, supported by main girders, straight and continuous, with large interstices and 5 meters in height, and two isolated marginal spans of 25 meters each, supported likewise by straight lattice-work girders, 2,5 meters high.

The abutments, as well as the four intermediate piers and the pier-abutments supporting the two spans of lesser length, are of solid masonry, and have with the exception of the northern abutment, which rests on the rock of the hill side, the height, above low-water mark, of 23 meters, determined by the amplitude of the largest flood known.

Excepting the pier-abutment on the right bank, which was laid dry shod and above low-water mark, the piers were sunk by means of compressed air and of metallic caissons, similar to those employed in the Minho international bridge, to depths ranging from 15 to 20 meters.

The abutment of the left, as well as the abutment and the pier-abutment of the right bank were set upon the rock without need of pumping.

The sheds and work-yard for the preliminary operations of erecting the platform were arranged on the left margin, where the width of the sandy beach and the straightness of the avenue offered favourable conditions, which the opposite side could not afford.

The setting in place of the main platform was effected, according to the usual way, by putting it up on the abutment and by successive advances; the erection of the platform on the span of the right bank was effected by advances and by temporary fixation to the extremity of the main platform. Respecting the platform belonging to the span of the right margin, where the rock is steep, it was put in place on the spot by means of scaffolding.

The macadamized roadway is 4 meters wide, and the side-

walks are 1 meter wide each, and covered with striated iron plate.

Entre-os-Rios bridge is the point of junction of two great high roads, putting in communication the two districts of Oporto and Aveiro and to which abut other roads of minor importance.

It is the second and the last bridge constructed on the bed of the Douro in Portuguese territory.

Not taking into account the wagonettes loaded with scrap iron, which served for the proofs of the platform, it was on the 1st December 1886, that the first vehicle passed over this bridge.

Designer of the primitive plan, engineer sr. *A. F. de Araujo e Silva.*

General contractor for the construction — *Société anonyme international de construction et entreprise de travaux publics de Braine-le-Comte* (Belgium), which elaborate the definitive project in accordance with the outlines of the first plan.

Representant in Portugal *of Société de Braine-le-Comte,* M. *E. Rolin.*

The avenues, formed by the two contiguous portions of the roads served by the bridge, were constructed by partial undertakings, under the direct management of the State.

Director of the whole construction, engineer sr. *A. Luciano de Carvalho.*

ROAD BRIDGES

(Pontes de estradas ordinarias)

1 album (nº 12) with 37 photographic views: Chaves bridge, over the Tamega, the side up stream — The same, seen down stream — Valley of the Tamega and Vidago bridge (mineral waters) — Bridge over the Cávado at Gerez; bridge «do Bico» (of the point), over the Cávado; Vizella bridge; «Ponte-feia» (hateful bridge), over a cascade in the river Homem — Valley of the river Lima and bridge of the same name — Regua bridge, over the Douro — Bridge Luiz I, over the Douro, and the suspension bridge which preceded it (two plates) — River boat for the navigation of the Douro — The same — Portella bridge, over the Mondego — Bridge «das tres entradas» (of three entrances), over the Alva and Alvouco rivers (three plates) — Sotam bridge, over the Ceira — Murcella bridge, over the Alva; Espinhal bridge, over the Eça; Taboa and Fiaes bridges, over the Mondego (two plates) — Sarzedo bridge, over the Alva; Sepulcro bridge, over the Pizão stream; Avô bridge, over the Alva; bridge over the Pomares stream — Villa Cova bridge, over the Alva; Barril bridge; Coja bridge, over the Alva; Pastor bridge — Abrantes bridge, over the Tagus — Portas do Rodam (upper Tagus) — The same — Villa-Velha bridge, over the Tagus — Espozende bridge, over the Cávado — Villa-do-Conde bridge, over the Ave.

Many and most remarkable specimens of *ancient bridges* are to be found still extant in Portugal, some erected in the time of the Roman dominion, and we shall now briefly point out those which are represented in the plates of our albums.

Such are:

In album nº 6, last plate, *Mirandella bridge,* over the river Tua, with eighteen arches.

In album n^{er} 19, first plate, *Barcellos bridge,* over the river Cávado, which had its pavement lately widened. It has five full centered arches and different radiuses: 9^{m},8; 8^{m},3; 7^{m},25; 3^{m},4; mean height 12 meters.

In the present album:

Chaves bridge, over the river Tamega, with sixteen arches at present visible, full-centered and of 6^{m},3 span, and maximum height of 6^{m},2, its construction dating from the time of the Emperor Trajan;

Avô bridge, over the Alva, prior to the 17th century, with one single arch of 18 meters span, 17 meters of mean height and 49 meters in length;

The bridge called *das tres entradas* (of three entrances), over the rivers Alva and Alvôco, erected about the end of the preceding century and formed of three converging parts, with one single arch of 13 meters over the Alva and two, one of 13 meters and another of 5^{m},8 over the Alvôco; mean height 10^{m},5, total length 140 meters; and finally:

Vizella bridge, of which we have no detailed information.

During the first quarter of the present century and even some years after, the war of the French invasion and the intestine struggles did not afford opportunities to look after these public improvements; up to 1811 the work was only of destruction, chiefly in the district of Coimbra, where the resistance offered to the invading army was more tenacious, and where we frequently meet with bridges restored, recording in lapidary inscriptions the cuts effected in these unhappy times.

From that epoch up to the present time the bridges erected constitute *three groups,* answering to different periods, which, in like manner to what we have observed in the history of Portuguese railways, may be distinguished with reference to common roads.

The first from the extinction of civil strife to 1862, the year

in which was promulgated the law dated the 15th July, concerning the general classification of roads, their construction, maintenance and police.

The second from the year 1862 to 1880, when Government, by the bill dated the 5th of March, acknowledged the necessity of having recourse to extraordinary means in order to complete the road system of the country, conceiving then the plan of an important loan and of general contracts to attain that end.

The third from 1880 to the present time is the period during which the works of construction, chiefly of district road system, attained greater development, plans being laid out on a very large scale, the most important constructive works being then projected and carried out.

To these three periods, therefore, are related as many epochs of progressive development in the construction of bridges for common roads.

In the first period, in which for a very long time predominated the idea of constructing and working the roads by means of private companies, few remarkable examples of such constructions can be mentioned.

The most noteworthy is that of the *Oporto suspension bridge* over the river Douro, 160 meters in length, to replace the boat bridge, established a little way below at the mercy of the capricious and impetuous current of that river. This great improvement gave luster to the reign of Queen Dona Maria II.

This structure in its turn gave way before the two floored bridge Luiz I[1], as represented in the three photographs contained in the 7th leaf of the present album.

Other specimens worthy of notice, and relating to the same period, are those of *Trofa bridge*, over the Ave, also a suspen-

[1] See album ner 10 — Bridge *Luiz I*, and album ner 16 — Oporto, Braga, monuments and edifices.

sion bridge still extant, and that of *Taipas,* over the same river, built entirely of solid masonry, with three full-centered arches of 10 meters span each and 16 meters of mean height, of which, we regret to say, no photographs were obtained.

The beginning of the second period coincides with the building of several bridges in the Villa Real district; among which we shall mention: *Cabril bridge,* with a single full-centered arch 12 meters in diameter, 22 meters high and 30 meters in length and the *bridge of Mondim-de-Basto,* with four arches, two terminal of 11 meters and two central of 21 meters, with wooden flooring and 107 meters of total length.

The works, however, that most distinctly mark this new era, rendering it eventful, were the two *bridges* called *do Bico (of the point),* successively built over the rivers Cávado and Homem, in the vicinity of Braga and of the confluence of the two streams, these structures deriving their name from the configuration of the banks.

These bridges, built entirely of stone, are formed of twelve full centered arches of $14^{m},6$ span, being eight in the first and four in the second, and they rise to the height of $15^{m},3$, measured from the sills to the parapets.

For beauty of design, value of workmanship and perfection of construction, these two joint structures stand pre-eminent above all other stone bridges in Portugal, and their location in one of the most delightful outskirts of the chief city of the Minho caused them to become a point of general resort for tourists.

To give an idea of the structure, we refer ourselves to the second plate in the fourth leaf of the album.

To the middle of this period belong the two similar bridges, that of *Regua* over the Douro, and the *Portella bridge* over the Mondego, represented in leaf 6th and leaf 10th of the said album.

Built nearly by the same time and finished, the first one in 1872 and the last in 1873, both with metallic superstructures and stone piers, they are the vestige of the partiality, which once enjoyed the bowstring girders, of superior polygonal contour, according to Schwedler system, to which obeys, as we have seen, one of the most remarkable constructive works of the Minho[1] railway — the bridge over the Ave.

The *Regua bridge* has 6 spans, 4 of 47 meters, one of $77^{m},8$ and another, a marginal one, of $16^{m},2$; this want of symmetry being due to the difficulty, which rose in the course of the construction on sinking the foundation of one of the pillars, and to the advisability of not establishing it in the navigable channel of so torrential a river.

The total length of this bridge is of 318 meters, including the abutments and corresponding piers, its maximum height being 25 meters.

For the construction of *Portella bridge* were appropriated the two spans not adopted in the Regua bridge, that structure remaining therefore with 4 equal spans of 47 meters each.

Its total length measures $207^{m},65$, the mean height of its pillars being $10^{m},3$.

Both bridges have timber floorings.

Their metallic superstructures, as well as that of a similar bridge belonging to the Minho railway, were manufactured at *J. G. Harkort's iron works* (Prussia).

Other bridges worth mentioning, for the major part built entirely of stone, were constructed during this period, such are:

Aveiro district

Canha bridge, over the Certima stream with three circular, depressed arches, of 12 meters chord and 2 meters rise.

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[1] See album nº 4 — The Minho Railway.

Bridge over the Caima, three arches, one of 14 meters and two of $9^{m},80$, rise $4^{m},9$;

Estarreja bridge, over the Antuan, three arches of 10 meters chord and $1^{m},34$ rise.

Rata bridge, over the Vouga, six arches of 8 meters chord and $1^{m},1$ rise.

Coimbra district

Sarzedo bridge, over the Alva, with three arches of 12 meters span each, depressed to $^{1}/_{3}$, with pillars and abutments $5^{m},5$ in height and approches 60 meters in length each (1st plate of leaf 13th).

Sotam bridge, over the Ceira, of one single arch of 8 meters span (4th plate of leaf 11th).

Espinhal bridge, over the Eça, with four arches of 6 meters span each (2nd plate of leaf 12th).

Villa Real district

Murça bridge, over the Tinhella, full-centered arch of 20 meters span and 33 meters height.

Varosa bridge, close to the confluence of the Douro, full-centered arch of 25 meters span.

Tavora bridge, close likewise to the confluence of the Douro, full-centered arch of 16 meters span.

Castello Branco district

Ponsul bridge, composed of three full-centered arches, diameter of each 14 meters, height 24 meters, width $7^{m},1$, length, including approches, 150 meters.

Portalegre district

Caia bridge, three circular, depressed arches of 12 meters chord and 2 meters rise, thickness of pillars $2^{m},7$.

Marvão bridge, over the stream of the same name, three

supported on columns established in the extensive grounds flooded by the Tagus on the occasion of great inundations.

The pillars of the bridge strictly speaking are of rusticated ashlar, having $14^m,9$ height over low-water mark, $3^m,26$ of thickness under the cornice and the batter of $27^m/_m$ per meter in the whole of its contour; they were founded with the help of compressed air at depths, the utmost of which reached 20 meters.

The pillars of the viaduct, on the left bank, are constituted by cast iron columns sunk into the ground by means of screws 1 meter and $1^m,4$ in diameter, the length of the columns summed together reaching 522 meters.

The girders of the bridge are $5^m,96$ in height, $4^m,80$ apart between their axis; the length of each is of $584^m,16$.

The width of the roadway is $4^m,4$ and of each of the side-walks for foot passengers $0^m,8$; the roadway is of common macadamized surface resting on incurvate iron plates, on which is likewise laid, with the interposition of a beton layer, the asphalt of the side-walks.

The length of the whole structure, of which, we regret to say, we are unable to forward the photographic view, is 1:214 meters, 620 meters belonging in a strict sense to the bridge.

The construction was carried out by general contract by the Fives-Lille Company in what respects to the two first, and by the firm Schneider & C^{ie} (Creusot iron-works) in respect to the third and last portion.

In the course of the last period, the instances of such constructions are neither as varied or as numerous, but on a general rule, the large works prevail.

In the first plan figures *bridge Luiz I,* over the Donro, a work truly monumental, which connected the city of Oporto with the suburban town of Villa Nova de Gaia. It has two floorings, the upper one formed by means of an exceptional

ribbed arch of 172 meters chord, standing 62 meters above low-water mark.

It forms the special subject of the photographs contained in album n^{er} 10, of which we treat in a separate chapter.

The *international bridge over the Minho,* of which we have likewise spoken when describing the constructive works of the Minho railway [1], with its double flooring to carry the railway and the common road, repeted conversely the example of the Vianna bridge, exchanging the ferry-boat by a firm roadway connecting thus the borders of the two conterminous countries.

The Braga district pursued the work undertaken in the preceding period in so distinguish a manner, erecting the two solid masonry bridges by degrees of boldest design:

Travassos bridge, over the Ave, with a single depressed arch of 18 meters span; height 13^{m},7;

Ruivaes bridge, over the river of the same name, with one single full-centered arch of 20 meters span; height 20^{m},48.

By the time of the erection of bridge Luiz I were likewise constructed over the rivers Douro and Tagus two remarkable metallic bridge:

Entre-os-Rios bridge, described already when referring to album n^{er} 11, specially devoted to this constructive work.

Villa-Velha bridge, over the Tagus, a little above the site picturesquely described by the name of Portas do Rodam, where the river flows confined between two high quartzite banks, which suggest to the beholder the idea of a colossal gateway.

It has three spans, the two marginal of 50^{m},4 each, and the central one of 65 meters, which allowed of the foundation

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[1] See album n^{er} 4 — Minho Railway.

being laid on the rock during the dry season by means of cofferdams and the drawing off of water in no considerable quantity.

Total length of the bridge, 163 meters; height of pillars, 30 meters; height of lattice girders, 5 meters.

Plates 16th and 17th of the present album give a perfect idea of the site, where this bridge was erected, and chiefly of the abrupt and lofty crags, which at that spot contract the bed of the Tagus, and across which, on the right bank, passes the Beira Baixa railway.

Plate 18th represents the structure.

Other metallic bridges of large spans and supported on solid masonry piers have been successively erected of late, namely:

Bridge over the Guadiana, in the province of Alemtejo, on the road to Mourão; eight spans of $32^{m},10$, the end ones independant for defensive considerations, this bridge being on a site so close to the border. The intermediate spans are formed of continuous girders.

Length of the roadway, $256^{m},4$; width between the parapets, 6 meters.

Constancia bridge, over the Zezere, and near the confluence of this river with the Tagus, and in the proximity of the Eastern railway bridge, already described; three continuous spans of $56^{m},25$ and $67^{m},50$. Height of pillars, 16 meters.

Foundation of the pillars by compressed air, at the depths of $19^{m},2$ and 9 meters beneath low-water mark.

Total length of the flooring, $180^{m},7$; width between the parapets, $5^{m},9$. Total lenght of the bridge, 200 meters.

Espozende bridge, over the Cávado, in the vicinity of the point, where the stream debouches on the Ocean; eight continuous spans of $33^{m},4$.

Foundation of eight piers effected by compressed air, at the utmost depths varying between $9^{m},25$ and $17^{m},05$.

Length of flooring, 268^{m},48; width between the parapets, 6 meters.

Villa-do-Conde bridge, over the Ave, and close to the spot, where this river flows into the sea; three continuous spans of 33 meters and 43^{m},2.

Sinking of the foundations of two pillars and one abutment effected by means of compressed air, at the utmost depths of 18^{m},2 and 22 meters.

Length of flooring, 115^{m},90; width between the parapets, 6 meters.

The construction of *Villa-Velha bridge* was executed by general contract with the *Société de Braine le-Comte*, that of the *Guadiana bridges* and of those of *Zezere, Espozende* and *Villa-do-Conde* being undertaken by the *Empreza Industrial Portugueza,* of Lisbon, with exception of the masonry work of the first of these bridges, which was effected by direct administration of the State.

As may be seen by the foregoing statement, the bridges built of stone, a material which is to be had in excessive abundance all over the major part of the country, have encompassed considerable spaces, the largest span measuring 25 meters at the Varosa bridge.

Iron has been a great help in cases where there were structures requiring laborious and deep foundations, and where the widths were great. Spans from 50 to 60 meters and upwards may be observed, above all others being truly remarkable the ribbed arch of bridge Luiz I.

Among the Government engineers intrusted with the direction of the works, to which this portion of the Catalogue refers more especially, we shall mention: srs. *Agnello Moreira,*

deceased, director of the construction of bridge do Bico, over the Cávado; *Heitor de Macedo,* dead too, director of the construction of Portella and Coimbra bridges over the Mondego; *Silverio Pereira da Silva*, director of the construction of bridges in the Aveiro district; *Agostinho Leite de Bettencourt*, ditto of bridges in the Portalegre district; *Augusto Fidié*, ditto of Ponsul bridge; *Frederico Pimentel,* ditto of Santarem bridge over the Tagus; *Mendes Guerreiro,* ditto of Villa-Velha bridge over the Tagus.

VIII

LISBON — MONUMENTS AND EDIFICES

1 album (nos 13) with 27 photographic views: Exterior panorama of Lisbon, seen from Almada — Interior panorama, seen from St. George's Castle — The Cathedral — Conceição Velha — Carmo, portal — The same, inside view of the church in ruins — The same, principal façade — «Casa dos Bicos» — Panorama of Praça do Commercio, St. George's Castle and the See — Praça do Commercio — The same — Triumphal Arch of Rua Augusta, in course of construction — Basilica of Estrella — Monument of Camões — Praça de D. Pedro, formerly Rocio — Avenida da Liberdade, monument to the Restorers (1640) — Pelourinho square — New Municipal Palace — Chief Market — Central railway station — Aqueduct of Aguas Livres — Alviella canal — Sources of the Alviella at Olhos d'Agua — Siphon at Sacavem, in course of construction — The same, nearly finished — The same, complete — The same, complete, on a larger scale — The same, construction of ancillary works — Water-works engine house at Barbadinhos.

Lisbon — The panoramic views, forming the subject of the two first plates of the album, being taken in a parallel and a perpendicular direction to the Tagus, define the site and aspect of this capital, situated in the western extremity of Europe and having at its disposal one of the finest sea-ports in the world.

The first, an exterior view of the city taken from Almada, on the opposite side of the Tagus, embraces the whole city from the Northern and Eastern railway station at Caes dos

Soldados down to Alcantara, the starting point of the Western railway, these two points being the limits of the principal section of the works for the improvements of the Lisbon harbour, which are now being carried into effect.

The second, an inside view, taken from the castle of St. George, begins at Praça do Commercio.

It represents on the foreground the regular blocks of the lower quarters; further off, towards the west, the hill sides crowded with buildings, most conspicuous among them being the Royal Palace of Ajuda and the magnificent church of Estrella, and it ends, at a distance, with the hills, one crowned by the church of Penha de França and another, a little nearer, by the chapel of Senhora do Monte.

In either of them, although taken before the latest improvements, is well marked the stamp of a modern city, which the all powerful hand of the Marquis of Pombal, first minister of King Don José I, impressed upon Lisbon after the earthquake of 1755.

To this catastrophe and to others, which came before in the course of centuries, must be attributed the small relative occurrence of vestiges of the past, and chiefly of monuments in a city so ancient and of so remarkable an history.

Our album is a reflex of this particularity, because it presents, after the two panoramas mentioned, the views of the Cathedral, of the churches of Conceição Velha and of Carmo, and with these ends the series of plates representing the archeological monuments.

We shall just mention «Casa dos Bicos», of which we only offer the photograph, as the representation of a singular curiosity of private house building in by-gone times.

The Cathedral (plate 3rd): The most ancient temple of Lisbon; it was in the beginning an Arab mosque, having been definitively consecrated to Christian worship in the 12th centu-

ry by King Don Affonso Henriques, the founder of Portuguese nationality.

Conceição Velha (plate 4th): It hardly has of ancient but its façade, a real architectonic gem and a precious relic, which the great earthquake spared, of the sumptuous temple belonging to that charitable institution, known by the name of Misericordia, which King Don Manuel caused to be erected in the first quarter of the 16th century.

Carmo (plates 5th, 6th, and 7th): By its graceful pointed arches, still erect, these ruins, a vestige likewise of the earthquake of 1755, show that this temple had been one of the finest specimens of Gothic architecture to be met with in Portugal.

It was founded about the close of the 14th century by the High Constable of Portugal, Don Nuno Alvares Pereira, to commemorate the victory gained on the field of Aljubarrota, that effectually secured the crown of Don João I and the independence of the country.

Luckily we have besides these monuments, and pre-eminent over all others, standing in its integrity, the church of Belem, a work eminently national, on which we shall dwell more particularly, when describing the monuments represented in the following album.

The reedification of Lisbon by the powerful impulse of Don José's minister shows itself in a most conspicuous way in the *Praça do Commercio*[1], a sort of vestibule leading into the city, which spreads itself in front of *Caes das Columnas*, and whose amplitude and rich decoration is shown in the plates of our album (8th, 10th, and 11th).

In the center of this square rises the commemorative mo-

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[1] Formerly known by the name of *Terreiro do Paço;* the English and Americans frequenting the port call it *Black Horse Square.*

nument of the rebuilding of the city, surrounded by groups and allegoric bass-reliefs and supporting aloft the equestrian statue of the then reigning sovereign; the whole being the produce of national art, which the great minister fostered amid so calamitous an epoch.

The monument, which confers so much honour on the school created at Mafra in the reign of Don João V, immortalized the name of the Portuguese sculptor Machado de Castro.

Partaking of the properties of the same school we have the *Basilica of Estrella,* whose dome commands in bold outline all the other buildings of the city, and on whose façade as well as in its interior Machado de Castro left indelible marks of his artistic genius.

Many years passed during which the transformation of Lisbon was interrupted by the calamitous events, which occurred and were prolonged even beyond the first quarter of the present century.

The reaction, however, came afterwards, and the improvements of the capital were pushed on uninterruptedly in such a way as to impart to it the complete features of the modern city, by which it is distinguished.

The *Triumphal Arch*, which for so long stood unfinished at the entrance of rua Augusta, is represented in the plates of of our album (9th, 10th, and 11th) in course of construction and in the complete state we see it to-day. Its completion brought to end the decoration of Praça do Commercio, enhanced already to a high degree by the monument erected to Don José I.

The *Praça de Don Pedro*, at the top of which, in the place where formerly stood the abominable Palace of the Inquisition, was built from 1842 to 1846 the National Theater, remarkable for its peristyle with Ionic columns and the high relief sculptures of its pediment; had its center adorned in 1870

with a monument erected to the memory of Don Pedro IV, the founder of the constitutional monarchy (plate 14th).

In the old Pelourinho square, on the spot occupied by the eastern block of buildings destroyed by a great fire in 1863, was raised, and in 1875 inaugurated the *Palace of the Municipality* (plates 16th and 17th), answering to all the requirements of a modern monumental building, and decorated inside and outside by Portuguese artists, with the exception of the French sculptor Calmels.

The confined Public Gardens of the lower town have disappeared and in its stead (plate 15th) has been thrown open the Liberty Avenue (Avenida da Liberdade), a broad and extensive *boulevard,* at the entrance of which rises the *Monument of the Restorers,* allusive to the liberation from Spanish yoke (1640).

At present the Avenue reaches to as far up as Val-de-Pereiro, new streets branching off on either side of it, constituting new quarters with buildings in varied style, disposed according to the precepts of modern architecture.

This great thoroughfare is brillantly illuminated with electric light.

In other points of the city were erected monuments to men distinguished in the country's history, the oblivion of three centuries having been at last redeemed by the raising of a statue to Luiz de Camões, owing to the action of the Portuguese sculptor Victor Bastos, to whose chisel is due the artist work.

In the old suburbs, now joined to the city, other quarters have been laid out and built, furnishing cheap and healthy accommodations to the inhabitants, who were sadly in need of them within the precincts of the ancient circumscription.

Improvement of another kind and of first rate importance characterize still this new period of edileship; we mean the water supply.

Already in the middle of the preceding century, during the reign of Don João V, the first step was made by collecting the waters to the north of the city and by the construction of a grand aqueduct, 25 kilometers in length, carried either underground or upon arches, a work which excites admiration even to this day, for the magnificent way in which it was carried out and for the benefit it conferred on the population.

The arches are 125 in number, the most remarkable being the thirty-five crossing the Alcantara valley close to Lisbon. Ten of the arches, which are pointed and of the largest, form the *Aqueduct of Aguas Livres,* whose greatest height is of $62^{m},29$, the respective arch measuring $28^{m},26$ of span.

It constitutes the principal subject of the 20th photograph.

However, the «Aguas livres» (free waters), as they were called after the stream of the same name, notwithstanding the works of search and the additions to the original stock, never yielded more that 6:000 cubic meters in every twenty-four hours, a supply equivalent to 30 liters per inhabitant.

Besides, the conveyance of water to the dwellings continued to be done by means of the barrel and the *aguadeiro* (water-carrier), a custom of which we see the vestiges in plate 7th of the present album.

From hence resulted the undertaking, which in 1869 the Lisbon Water Company (**Companhia das Aguas de Lisboa**) took in hand, of conveying to Lisbon the waters of the Alviella river, gathered at the source, which lies eastward from the capital, at 11 kilometers distance from the small town of Pernes, in the Santarem district.

The last photographs of the present album are devoted to this important enterprise, and specially to one of its constructive works more worthy of mention — the siphon at Sacavem.

The Alviella canal measures 114 kilometers in length, being carried mostly at mid height of the slope.

For the passage of small valleys were constructed arcaded aqueducts according to the general types of arch depressed to 1/5, with 4 meters span, or of full-centered arch with 5 meters diameter.

For the passage of the large valleys were applied siphons formed by a line of cast iron pipes, 1 meter in diameter, laid at the bottom on constructive works, in order to allow free passage to the common flowing streams.

The 111 passages over arches have the aggregate length of 3:640 meters, the arches being 600; the siphons, among which is noteworthy the one at Sacavem, are 50 in number, with the total length of 15:000 meters.

The Sacavem siphon has 900 meters chord and 34 meters rise, and crosses the river by means of an inverted arch of 45m,50 chord and 13 meters rise, formed by the very same pipe carrying the water, and for this reason the pipe is at this point made of laminated iron strengthened with ribs.

The arch rests on masonry abutments, the foundations of which were sunk through thick beds of fluid mud to the maximum depth of 40 meters, in order to reach the solid bottom, this being effected by means of tubes full of concrete, that serve as basement to the structure.

The tunnels are 94 in number and their aggregate length is 17:540 meters, the principal one being 2:700 meters in length at the maximum depth of 40 meters.

The discharge of water from the Alviella is of 40:000 cubic meters, being received in a reservoir situated in the garden of the old convent of Barbadinhos, close to the principal water-raising engines. The building, where they are established, is represented in the last plate of the album.

The Barbadinhos reservoir, whose base is at 27 meters above the sea level, and whose holding capacity is of 10:280 cubic meters, is of rectangular form with the dimensions of

78^{m}×40^{m}, being divided into two equal compartments with groined vault with 3^{m},60 opening and 0^{m},60 rise, resting on pillars of solid masonry with 0^{m},40 of square section at the side, and 4 meters in height.

For the purposes of water supply the city of Lisbon is divided into three zones: lower, middle and upper.

The lower zone is supplied by two reservoirs:

That of Veronica, base 66^{m},62 above the sea level, capacity 4:978 cubic meters;

That of Principe Real, base 66^{m},57 ditto, capacity 880 cubic meters.

This last receives water from the Anadia reservoir in the middle zone, and also from that of Veronica by means of a pipe connecting these two reservoirs.

The Veronica reservoir is fed by the Barbadinhos engines, which raise the waters from the Barbadinhos to the Veronica reservoir and for the Monte cistern. These engines are 4 in number and 120 horse-power each, on the working beam system; constructed by Messrs. Wilson & C.°, of Rouen.

From the Monte cistern the water is conveyed by a pipe of 0^{m},61 diameter to the Anadia reservoir, which supplies the middle zone, having capacity to hold 10:000 cubic meters, its base being at 92^{m},34 above the level of the sea.

The upper zone is supplied by the Pombal reservoir, whose base is 115^{m},88 above the sea level, having capacity to hold 6:000 cubic meters. It is fed by the old aqueduct of Aguas Livres, already described, or by the waters of the Alviella, raised from the Anadia reservoir by a 40 horse-power horizontal engine.

The Penha de França cistern is fed from the Pombal reservoir by means of a 0^{m},25 diameter siphon, the base of this cistern being 104^{m},61 above the sea level. From Penha de França is distributed the water supplying the eastern portion

of the upper zone, namely: Monte, Graça, and St. George's Castle.

Directors of the construction of the whole undertaking, from the surveys to the close of these works, the Portuguese engineers srs. *J. P. Cabral Couceiro* and *J. P. Sousa Gomes.*

Director of the Company, dr. *C. Z. Pinto Coelho,* lately deceased.

Present engineers, srs. *F. Borges de Sousa* and *J. E. de Sant'Anna Castel-Branco.*

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LISBON, LEIRIA — MONUMENTS

2 albums (nos 14 and nos 15)

The first with 21 photographic views: **BELEM** — Temple and monastery of Jeronymos, «Real Casa Pia» (Orphans institution) and Industrial and Commercial Museum; general view — Anterior doorway of the church — Lateral door — Interior, side of the choir — The same, side of the principal chapel — Cloister, outside view — The same, inside view — The same, the same — The same, the same — Tower of Belem. — **BATALHA** — Temple and monastery, general view — Frontage of the temple — The Founder's Chapel — Unfinished chapels — Royal cloister, inside view — The same, outside view — The same, the same — The same, the same. — **ALCOBAÇA** — Temple and monastery, general view — Tomb of Don Pedro I. — **MAFRA** — Temple and monastery, general view.

The second with 12 photographic views: **BATALHA.** — Front view — Principal doorway — Lateral façade — Another front view — Royal cloister, outside view — Mausoleum of Don João I — Tomb of Infante Don Henrique — Tomb of Infante Don João — Cloister's fountain — Unfinished Chapels, doorway. — **ALCOBAÇA** — General view — Castle of Leiria.

BATALHA

Of the four monuments represented in the plates of these two albums in the following order, **Belem**, **Batalha**, **Alcobaça**, **Mafra**, the second is, assuredly, the most truly national and the most remarkable as a magnificent product of art.

It signifies the performance of a vow made on the 14th of August 1385 by King Don João I, on entering the battle-field of Aljubarrota against his namesake the King of Castile.

At the sign of the princely founder, and under the invocation of Santa Maria da Victoria, the independence of Portugal having on that day been insured, rose the imposing pile, that, for magnificence of proportions, purity of lines, gracefulness of form and moderate use and finish of ornamentation, may be ranked among the most celebrated specimens of Gothic architecture.

Don João I had not the satisfaction of beholding his work complete, and this is the reason why the construction dragged on for the whole length of the reigns of his immediate successors, and necessarily felt the influx of subsequent epochs.

In its general appearance the monument however suffered nothing, the execution of the work having obeyed in the major part of the time to the original design, of which give proof the façades, excellently represented in plates 11th and 12th of the first album and in the first four plates of the second.

The same impression is felt on viewing the inside of the temple, which measures from the principal entrance to the further end of the high-altar $80^{m},21$ in length and $33^{m},30$ of greatest width at the transept, being divided by 16 pillars into nave and aisles, the first being $32^{m},40$ in height and $7^{m},44$ in width.

The nave and aisles with the pillars composed of clustered columns of slender shaft, rising simply and gracefully up to the springings of the vault, with the only embellishment of the flowered ornaments at the tops, impart to the whole that religious and contemplative character, which is so peculiar of the finest Gothic cathedrals.

The harmony of the architecture displays itself likewise internally and externally in the annex of the *Founder's Chapel* (plate 13th of the second album).

This is the place of royal sepulture, exhibiting ornamental work in keeping with the greatness of the noble personages

whose remains are there interred. At the center stands the sarcophagus of King Don João and of his Queen Dona Filippa, and around repose their illustrious offspring, the Infantes Don Pedro, Don Fernando, Don João and finally Don Henrique, to whose enterprise the Portuguese are indebted for the opening of the way to their most glorious discoveries, his noble motto *talent de bien faire* being conspicuously sculptured on the frieze of his sarcophagus (plates 7th, 8th and 9th of the second album).

To the same epoch, and bearing likewise the same imprint, belongs the *Chapter-house,* square in form, each side measuring 18^{m},90. It is celebrated for its bold surbased vault without any intermediate support, and so it has stood for centuries without the slightest symptom of decay, in spite of the earthquakes that in other parts of the monument have left no inconsiderable marks of ruin.

Of the same epoch is also the *Royal Cloister* (plates 15th, 16th, 17th and 18th of the first album).

But in the mullion-shafts and above all in the cross mullions stayed by them under the pointed arches and in the fountain at one of the angles (plate 6th of the second album) are already evident the traces of a posterior epoch, in which prevailed the taste for fanciful ornamentations.

And, where this transition appears more marked and more rapid, is in the *Unfinished chapels,* which have been named so on account of their incomplete state.

They are situated in the prolongment of the body of the church, whose principal chapel they overwhelm, concealing it partially from view and depriving it of light. This is the only infraction, though incomplete, of the general plan of the fabric.

This infraction signifies the violation of the thought, which presided to the erection of the Founder's chapel; it took place

in the reign of Don Duarte, successor and son of King Don João I, the purpose being to found another royal mausoleum with more magnificence and pomp.

The edifice is of octagonal form and independent of the main building, from which it is separated by a rectangular court. The work of the Unfinished chapels at its beginning shows obedience to the general design, but in the doorway, which, with its form and double aspect constitutes a beautiful artistic gem, is evinced the infidelity of the new architects, by the adoption of a different style, the florid Gothic, which prevailed during the reign of Don João II and chiefly during the reign of Don Manuel.

Standing in front of this doorway or better inside the chapels, one would think himself opposite a fragment of the church of Santa Maria de Belem, of which we shall treat soon; and would even be struck by a sort of resemblance of the anterior decoration with what Indian art whose influence on Portuguese architecture of the 16th century is undeniable, produced of most beautiful in this style.

But the infringement of the primitive ordinance did not stop here: over the doorway and in the upper and incomplete portion of the chapels disappeared in its turn the Manuelino style and in its stead is visible the Renaissance style, which began only to be appreciated in Portugal in the time of Don João III, during which was built the last portion of the Unfinished chapels.

It was therefore on good grounds, that Vilhena Barbosa, a distinguished Portuguese archeologist, not long since deceased, indicated as an excrescence on the monument of King Don João I the annex of the Unfinished chapels, in spite of the splendid ornamentation of its doorway.

BELEM

The monuments of Belem, a temple and a castle situated in the capital and on the river side, close to Praia do Restello, from whence, after a devout prayer in the primitive chapel, Vasco da Gama embarked for the discovery of India, are copiously and perfectly represented in the first ten plates of album n^{er} 1.

The church of *Santa Maria de Belem,* commonly called «dos Jeronymos» after the monastic order to which it was from the first confided, is the most complete specimen of the architectural style, half Gothic, half Renaissance, with some traces still of the Arab and of the Indian, designed by the name of florid Gothic, and in Portugal also by the name of Manuelino, as it was during the reign of Don Manuel that it reached its highest degree of splendor.

To this same style belongs the façade of the church of Conceição Velha, dating from the same epoch, and to which we made reference when treating of album n^{er} 13, *Monuments and edifices of Lisbon,* and of our own time is the adaptation, made with much talent, of this same style to a modern building devoted to a quite different purpose and that we have pointed out also in the above mentioned album — the Lisbon central railway station.

The two façades of the Jeronymos are most typical with their profusion of interlaced arches, of different festoons, of graceful statuettes, of lace-like moldings, of all sorts of fanciful arabesques (plates 1st, 2nd and 3rd of the first album).

Not less typical are the nave and aisles with their lofty and slender columns, their sculptured vaults, their mullioned and comparted windows producing effects of light, which only Rembrandt and Gerard Dow knew how to transport to the

canvas, and of which our photographs seized well the charm (plates 4th and 5th of the first album).

Finally the *cloisters* are in keeping with all these beauties of lines and ornamentation, which, if they do not strike with the deep reverence or inspire the meditation to which we feel irresistibly inclined on beholding the Batalha monument, still they mark a brilliant epoch in the history of Portuguese architecture.

And, as we have seen at Batalha the Unfinished chapels disagreeing with the whole fabric, at Belem we see the last architect surprised, and for that reason not a good master yet of the beauties of the Renaissance style, finish the temple with a great chapel, which on the outside is nothing more than a heavy masonry case, and in the inside but a gorgeous exhibition of polished marbles, in disagreable contrast with the first part of the monument.

The castle or *Tower of Belem,* represented in plate 10th of the album, is situated below stream at some distance from the church, on a projecting point of the beach.

It is a small, but precious, pattern of the military architecture of the 16th century, giving indication in all its details of King Don Manuel's time.

Beside the temple in its western extension has been erected a modern building (1st plate of album n^{er} 1) in the same style of the adjoining monument, but simply ornamented.

In its eastern wing is established the «Real Casa Pia» or orphans institution, and in the western wing the Industrial and Commercial Museum, founded both by the Government.

ALCOBAÇA

This should be according to tradition the first monument to mention, as its foundation-stone was laid by the first Portu-

guese monarch on the 2nd day of February 1148, in performance of a vow made on the occasion of the taking of Santarem from the Moors.

But, so many have been the changes there effected in the course of centuries, and often with so little judgement, that the monument of Don Affonso Henriques has completly lost the antique stamp of mædieval times.

In this enormous pile one meets with vestiges of all ages and of all styles of art.

Its extensive front, represented in plate 19th of the first album and in the 11th of the second, measures 221 meters in length, and on it are manifestly shown the successive influences of the times subsequent to the foundation.

The pointed arches of the church's doorway, belong, according to the opinion of Vilhena Barbosa, to the primitive construction, as well as the three windows of the portion of the edifice immediately above it, the central window being of circular form.

Everything else, however, is of posterior times, such as pilasters, entablatures, towers, statues, the last of colossal size, being of Carrara marble those of St. Benedict and St. Bernard, standing at the sides of the principal doorway.

The reconstruction of the monastery's wings dates from the 17th and 18th centuries, the façades having nothing of particularly remarkable unless their length, the meanness of their windows and the monotony of the whole.

The temple is spacious inside, the vaults and the semicircular disposition of the apsis, with the high-altar in the center, indicating still its ancient origin.

That which, however, attracts us there and excites our admiration to a high degree, are at the transept the stately sepulchral monuments of the *Royal Pantheon,* which is prior to that of Batalha.

The sarcophagi of King Don Pedro I and of Dona Ignez de Castro, his luckless consort, of whom, the Portuguese epic poet hath said — «E'en after her decease, as rightful Queen was crowned», are master pieces in their style, and even more worthy of admiration because they date from the 14th century.

The *cloisters,* five in number and constructed one after the other, point out well the changes in architectonic styles from the 13th to the 17th century.

The *Cloister of Silence,* in particular, the first in chronological order, and built by King Don Diniz, with its great pointed arches, each of them containing a series of three arches similar in shape, supported on double mullion-shafts, having above a large round light with radiating mullions, though much decayed by time, is even now one of the finest in Portugal.

MAFRA

The *Church and Monastery of Mafra,* at present a royal palace, situated at 40 kilometers distance to the north of Lisbon, and represented by its general façade in the last plate of the first album, constitute a monument of relative modern age, its foundation dating from the first quarter of the last century.

This colossal structure, which in plan represents a square, each side measuring 246 meters in length, was raised from its foundations in the golden reign of King Don João V, who built it with the magnificence of which there was no example extant in the Peninsula, save the Escurial.

The general ordinance of the building is classical.

The church, specially in that portion pertaining to the dome, reveals an imitation of the Basilica of St. Peter at Rome; it served afterwards as norm for a similar fabric erected at Lis-

bon, and to which we made reference when treating of the preceding album — the Basilica of Estrella.

Marble is profusely employed every where, either in the execution of the architectural design, or in the sculpture of innumerable statues.

From thence sprang up and there flourished the artistic school, which at the close of that century and after the earthquake of 1755 so signal service had to render to the capital of the Kingdom, inhancing the work of its reedification with the fruits of diligent study and high inspiration.

All the four monuments represented in the plates of the albums, to which we have referred, have been carefully preserved by the Portuguese Government, and there is besides an institution — *The Royal Society of Portuguese Civil Architects and Archæologists* (Real associação dos architectos civis e archeologos portuguezes), most solicitous in their preservation.

The monuments of Alcobaça and Batalha have not only suffered from the injuries of time, but they have likewise in the beginning of the present century suffered under the vandalic and rapacious hand of the invading soldiery coming from beyond the Pyrenees.

By a decree of Queen D. Maria II, Alcobaça was ordered to be preserved as an historical monument.

Batalha and Belem have been, we might say, religiously restored, as may be seen by the difference in the general effect of the prevailing tone in some of our photographs and more particularly, with respect to the first monument, in the 2nd plate of album n^{er} 15.

IX

OPORTO, BRAGA

MONUMENTS AND EDIFICES

1 album (nr 16) with 19 photographic views: **OPORTO** (district) — Oporto: panorama of the city — Cathedral, lateral elevation — The same, cloister — The same, the same — Churches of San Francisco, general view — Church of San Francisco (appertaining to the ancient convent) — Torre dos Clerigos — Santo Antonio Hospital — Exchange, covered court — Ferreira Borges Market, inside view — Minho and Douro railways station — Church of Leça do Bailio, near Oporto.
BRAGA (district) — Principal façade of the Collegiate church of Guimarães — Prehistoric monument of Gerez; Collegiate church of Guimarães; Roman road of Gerez; Villa do Conde (Oporto district).
AVEIRO (district) — The Aveiro lighthouse (nearly finished), general view — The same, principal elevation.

Oporto — The panorama represented in the first plate of our album embraces only one portion of the city, the one clustering in amphitheater on the right bank of the Douro, between the Virtudes supporting wall and the Fontainhas public walk.

Upon the table-land above the city stretches out in varied ondulations from the Minho and Douro railways station on the east to as far as the Boa Vista fields on the west.

On the right side of the Douro the city extends itself as far as the mouth of this river and by the sea side, where stand

agglomerated in succession the small towns of **San João da Foz**, **Mattosinhos** and **Leça da Palmeira**, as so many suburbs of the city, served by two lines of tramways.

On the opposite bank is situated **Villa Nova de Gaia**, whose traffic and population alone are equal to those of a considerable town.

On commanding points stand out in the panorama, to the left **Torre dos Clerigos**, to the right the **Cathedral**, two characteristic monuments in the city's outline.

The cathedral, which the three following plates represent, specially, the first by the lateral elevation, and the two others by the cloister, is, after the small temple of Cedofeita, anterior to the Arab domination, the oldest monument in the city.

Setting aside the diversity of aspect, for which contribute in part the building materials, limestone at Lisbon, and granite at Oporto, each blackened by time in a different tone, the cathedrals of these two cities offer many points of analogy.

The memory of the foundation of the Oporto cathedral is lost about the 6th century; of what, however, the temple had been in the beginning of the Middle Ages, nothing is left.

What there is of more ancient in the body of the church and in the transept, dates from the 11th century, and is due to the restoring impulse of Don Henrique of Burgundy and of his wife Dona Thereza, of whom was born Don Affonso Henriques, the founder of the Portuguese monarchy.

The vestiges of Romanesque architecture are evident there with all the traits of simplicity and even of rudeness, which distinguish it in Portuguese specimens.

The last reconstruction of the temple is far posterior and relatively modern, dating from the beginning of the 18th century, a time during which prevailed in Portugal a false taste for the Italian architecture, of which the city of Oporto exhibits frequent examples.

In the old *church of San Francisco,* the one belonging to the convent of monks, and represented in the general view, plate 5th, and in the special view plate 6th, we see still the influences of an ancien epoch, more religious and full of saving faith. The apsis is of the 15th century.

Torre dos Clerigos, however, is a model of the Italian style introduced into the country.

Designed, as well as the modern part of the cathedral, by the architect Nicholas Mazoni, it was erected about 1750. It measures nearly 70 meters in height, being therefore one of the highest in the world, deriving from this attribute and from the general lines of its contour a certain monumental character, which redeems it from defects of that school so lavish of heavy ornaments.

To this epoch belongs, though planned in a different style, the great *hospital of Santo Antonio* or of the «Misericordia», of whose design merely one fourth part was carried out, its principal façade having been not long ago enlarged. Its foundation dates about 1769.

According to the project, the building was to occupy a quadrangular surface, in a position facing the cardinal points, its perimeter being nearly 700 meters.

The portion built in the principal façade and that facing the south display the enormous proportions and the massive pomp of the projected structure.

The architectural style, subject to all the severity of the Tuscan order, contrasts in its simplicity with the superabundant ornamentation caracteristic of the religious buildings of the same epoch.

From this time onward, the architecture of the principal edifices of Oporto obeys to the evolution, which manifested itself in the capital after the earthquake of 1755.

The second city of the Kingdom had likwise, barring the

proportions of that great personage in Portuguese history, its own Marquis of Pombal, in the person of the «corregedor» Francisco de Almada e Mendonça.

In a like manner to what took place in Lisbon, the epoch was marked by the opening of new thoroughfares, laid out in straight lines. Such, for instance, is the Almada street, which stretches still from the vicinity of Don Pedro square to Campo da Regeneração, and even more remarkable is San João street, normal to the Douro, at whose quay it commences (see panorama, 1st plate), most broad for the time, and lined with stately houses, some pompously decorated according to the Doric style and crowned with Grecian pediments.

To the religious monuments overlaid with ornaments, on purpose to command public admiration, succeeded the civil edifices having no style whatever on the outside, verging often to meaness and characterized solely by a regard for utility. Such are the barracks af Santo Ovidio, the jail (cadeia da Relação), the San João theater, all built by order of Francisco de Almada and in the point of view of art not very worthy of photography.

Erected in our own times we have other buildings at Oporto, which the album represents, attesting the great advancement of the city in late years.

New and wider streets were opened, more modern and confortable quarters were laid out; the tramway system was carried to the principal points of the city, even to the highest; the street pavements, formerly composed of large irregularly-jointed and slippery flags, were replaced by regular parallelopipeds of appropriate stone; the waters of the river Sousa, brought from a great distance and raised to the highest points, have been conveyed in pipes and distributed throughout the city, and the **Cristal Palace**, on a commanding situation over the Douro, opposite the picturesque and charming pros-

pects of the city and environs, with the Ocean for background, has been opened by private enterprise to all public amusements.

Plate 9th represents the *court of the Exchange,* a modern edifice erected over the ruins of the convent of San Francisco, according to the principles of the Tuscan order, and situated opposite *Infante Don Henrique square.*

This building, remarkable for its principal staircase, that shows how far can be carried the delicacy of workmanship in granite ornamentation, and for its saloon of honour, decorated down to the minutest details according to the Arab style of the Alhambra; displays these works performed exclusively by Portuguese artisans and master-workmen, who have created there a school for imitation.

Under the point of view of native work, is shown the photograph, which for this reason is more deserving of attention, representing the metallic roof and supporting columns in the court of the said building, made in the workshops of the «Empreza Industrial Portugueza» of Lisbon (Santo Amaro).

As a specimen of work of the same description and in similar conditions is offered likewise the inside view of *Ferreira Borges Market,* built by the Municipality between the street of this name and Mousinho da Silveira street, the joint work of the «Alliança» Company, who own the Massarellos foundry, at Oporto, and of the above mentioned «Empreza Industrial Portugueza» (plate 10th).

The principal building of the Minho and Douro railways *station at Campanhã,* represented in plate 12th and more fully in another album [1], shows also in its central body the per-

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[1] See album n^{er} 4 — The Minho Railway.

fect workmanship of the stone cutter in the finest granite of the neighbourhoods of Oporto.

Northward, beyond the Douro, there are other monuments and edifices that, besides their archeological value, are most important in the point of view of architecture and of constructive art.

Such is the ancient *Monastery of Leça do Balio,* at 7 kilometers from Oporto, and represented in plate 13th of the album.

This most valuable specimen of primitive Gothic architecture partakes of the temple and the fortress.

In the pointed arches of its doorway, in the cusps of its lights, in the tracery of its rose-window, is well impressed the religious stamp; in the battlements that crown the walls, in the massive square tower, annexed and advanced beyond the body of the church, is evident the defensive purpose, that the architect had in sight.

The foundation of the monastery dates from the 10th century, but the military cast was solely imparted to the fabric in consequence of the donation of this monastery to the order of St. John of Jerusalem in the beginning of the 12th, during the government of Queen Dona Thereza.

Its reconstruction under the actual form dates from the 14th century and reign of Affonso IV, and was subjected to the rules of the art of war in consequence of the constant menacing raids of the Moors from Andaluzia.

The baptismal fount with admirable carvings, contrasting with the severe aspect of the whole building, speaks of a posterior time, and it rather seems to be a production of the period, in which the Gothic florid style obtained.

Further of and more to the north lie the two cities of **Braga** and **Guimarães,** rivals to-day much more so than they ever were, and both very rich in memorials of ancient architecture, as well as in historical remembrances.

Another album of the series [1] shows some specimens in the views of the cathedral and of two private mansions.

The *Braga cathedral,* whose primitive foundation in another site is traced back to the time of the Roman dominion, is indebted for its original and principal reconstruction, as well as nearly all the cathedrals in the Kingdom, to the first Portuguese Kings.

What there is of most remarkable and beautiful in the building, artistically speaking, is the work of the great chapel, rebuilt in the 16th century, pursuantly with the inspiration of the Gothic florid style, performed in such a way as granite will allow.

The frontage, reproduced in one of the plates, is almost in its entirety an example of the architectonic school prevailing in Portugal during the three first quarters of the 18th century, and to which we have already referred above when treating of the Oporto monuments and edifices.

The *church of Nossa Senhora da Oliveira* at Guimarães, represented in two of the photographs of the present album, is not as old as the Braga cathedral, but attached to it are historical traditions of the highest value for Portugal. Suffice is to say that in its baptismal fount, still preserved there, King Don Affonso Henriques received the first sacrament; this circumstance won for the city the title of «cradle of the monarchy» (plates 12th and 15th).

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[1] See album n^{er} 18 — Braga, Santarem, Evora — Monuments and Edifices.

The primitive foundation of this church dates from the 10th century, and its principal reconstruction from the 14th century, in the reign of Don João I, the founder of the Batalha monument, and who in performance of a vow went on foot from the field of Aljubarrota to carry to Nossa Senhora (Our Lady) da Oliveira his offerings, among which were precious spoils, abandoned by the King of Castile in his camp and religiously preserved to this day.

The church of Nossa Senhora da Oliveira was not raised before the King's own eyes, and that is the reason why it is not in keeping with the magnificence, with which Don João I erected the monument of Batalha.

Notwithstanding, in the pointed arches enclosing the doorway and in the light of the central body of the church it is easy to recognize the impress of the period of its first reconstruction.

Everything else in the façade is posterior and incongruous, above all the pilaster with Ionic capital, which most falsely adorns the corner on the right.

Besides the cities of Braga and Guimarães, one meets throughout the whole province of Minho with specimens of ancient architecture, as, for instance, in Caminha, at the mouth of the river Minho, the principal church in the Manuelino style, and at Vianna, the private mansions of Carreira street decorated according to the graceful details of the same style, particularly the one belonging formerly to the Tavoras.

We will still mention especially as forming the subject of one of the plates of the present album **Villa do Conde**, belonging to the Oporto district, and remarkable for its three ancient monuments:

— the principal or mother-church, founded in the time of King Don Manuel;

— the Santa Clara monastery, originally founded in the 14th century by Prince Don Affonso Sanches, son of King Don Diniz, and incompletely rebuilt in the last century, as shown in the photograph (plate 17th);

— the aqueduct, which supplied the convent, constructed by Filippe Tercio, architect of King Filippe II, the head-spring being at 7 kilometers distance and the number of arches being 999, the last of which are figured in plate 17th.

THE AVEIRO LIGHTHOUSE

The two last plates of the present album represent an edifice of quite a different description, in relation to all those of which we have been treating up to this moment, and so recent that it has been completed only a very short time ago, and is on the eve of its inauguration.

We allude to the **Aveiro lighthouse.**

As an irrefragable proof that Portugal endeavours to fulfill the obligation of illuminating its extensive coast, there is the Aveiro lighthouse, filling the great gap, which exists between the Senhora da Luz lighthouse, close to the mouth of the Douro, and the Cabo Mondego lighthouse, near the mouth of the river of the same name.

Situated at 100 meters from the sea and in front of the river Vouga estuary, whose waters together with those from the sea spread through a network of innumerable canals, anastomosing around the town of Aveiro or extending in a parallel manner along the shore line; this lighthouse is erected amidst the rows of dunes, which stretch beyond the range of sight, both to the north and to the south.

It is mainly composed of a tower of circular section rising out from the basement, which is $7^{m},50$ in height. This basement corresponds to the annexed buildings, and rests along

with them, upon the concrete bloc of the foundation, which is strengthened with a thickness of 11 meters and made firm by piles driven into the indefinite bed of underlying sand.

The sill of the principal door is nearly $1^m,40$ above the level of the highest tides.

The shaft of the tower measures $44^m,50$ in height, and 3 meters at the machiculation and cornice, the height of the luminous focus above the mean level of the sea being of $61^m,23$.

At its lower section the shaft of the tower mesures 11 meters in diameter and 6 meters at the upper section.

The cylindric empty space inside the tower is 4 meters in diameter and lighted by eight windows disposed in vertical rows, four on the sea side and four on the land side.

The staircase develops itself into about eight helical windings and is composed from the ground floor up to the floor of the light-room by two hundred and sixty-two stone steps, fitted on one side in to the wall, being furnished on the other side with a metallic hand-rail.

From the floor of the light-room to the lantern platform there is a metallic stair of twenty-six steps.

The lantern is formed by a cylinder, $3^m,66$ in diameter and $5^m,30$ in height, covered by an hemispherical dome. The cylindrical portion is glazed in $2^m,90$ of its height, measured from the dome downwards.

The apparatus is dioptric and of first order; the light sparkling, in groups of four white flashes, shewn successively every two minutes; fuel employed, petroleum.

The building adjoining the lighthouse has two floors, and is formed by a central projecting body with two wings.

In the central body, toward the front or land side, on both floors, are the arrangements and lodging house for the principal officers in the lighthouse service.

On the side looking seawards, in the same part of the building, on the ground floor, is the petroleum store and on the first floor the store room for instruments and apparatuses.

In each of the wings and on each of the floors are arrangements for the dwelling of the employés' families with a kitchen and four rooms.

The construction of the lighthouse was effected by means of inside and outside scaffoldings: the inside scaffolding supported on vertical trestles successively increased as the tower rose, the outside one laid on rafters fixed to the masonry walls of the tower.

The corners, the platband, the machiculation, the cornices, the parapet, the window and door frames, are of stone extracted from the granite quarries of Ribeiradio and Agoncida, situated in the inland townships, the former at 47 and the latter at 37 kilometers distance from the site of the work.

The escutcheon with the arms placed at the top of the principal window is from the marble quarries of Pero Pinheiro near Cintra, in the Lisbon district, having been set up in the last days of the reign of King Don Luiz I.

The material used in the masonry work came from the red sandstone quarries of Eirol, in the township of Aveiro, being coated afterwards with hydraulic plastering, absolutely necessary in consequence of the quality of the stone, subject in a high degree to atmospheric influences.

The lime came from the limestone deposits of the township of Anadia, from which the public works of the north of the country have drawn large supplies; as hydraulic lime, this material has rendered excellent service in the southern breakwater of the Aveiro bar and in the bridges we have already mentioned, not only of the district, but also in the bridges of the Minho and Douro railways.

The cement employed was from English source with the

Elephant brand, and likewise from France, manufactured by Lonquety, Demarle & C^ie^, of Boulogne-sur-Mer.

The principal timbers used are of American pitch-pine from Canada, the others of pine-wood from the forests of the district.

Close to the Aveiro lighthouse, at the head of the southern breakwater of the Aveiro bar, is established in an iron shelter a Siren, or sonorous apparatus, with intermissions of 2′ in 2′ on the system of Holmes, Sautter, Lemonnier & C^ie^.

The sound is produced 8 meters above the level of the high tides.

The steam-generating and air-compressing machines were established in a separate house, at 125 meters distance from the head of the breakwater.

The design for the Aveiro lighthouse and its dependencies is from the engineer sr. *Benjamim Cabral*, formerly Inspector general of telegraphs and lighthouses.

The engineer charged with the construction was sr. *J. M. Mello de Mattos*, chief of section in the respective hydraulic circumscription.

The metallic superstructure and the optic apparatus were supplied by the firm Barbier & C^ie^, of Paris.

The access to the lighthouse is by the excellent road stretching from Aveiro on level ground, amidst the canals of the estuary and the adjacent plain reclaimed already by agriculture.

X

COIMBRA — MONUMENTS AND EDIFICES

1 album (nº 17) with 41 photographic views: General view of Coimbra — Sub-Ripas palace, the seat of the Telles family — The old See (ancient cathedral), principal façade — The same, general view — The same, the Holy Sacrament's chapel — The same, Principal altar — The same, St. Peter's chapel — The same, interior of the temple — The same, the same — Santa Cruz, frontage of the temple — The same, Cloister of Silence, outside view — The same, the same, inside view — The same, the same, the Queen's Fountain — The same, pulpit — The same, choir — The same, tomb of King Don Affonso Henriques — The same, tomb of Don Sancho I — The same, tomb of Prior Don João de Noronha — The same, sacristy — University, the colleges' court — The same, botanical garden — The same, chemical laboratory — The same, library, outside view — The same, the same, inside view — The same, the same, ceiling — Cellas monastery, cloister — Santa Clara, remains of the primitive monastery — The same, cloister of the new monastery — The same, the same — The same, tomb of Queen Santa Isabel — Monastery of Lorvão, general view — The same, tomb of Queen Santa Theresa — The same, inside of the choir — The same, the same — Outside view of cloister — The same, inside view of cloister — Braga cathedral, frontage; Santa Cruz de Coimbra, the same; Old See, the same; Botanical garden and old monastery of San Bento, now the Lyceum.

The city of **Coimbra**, picturesquely seated on the right margin of the Mondego and in the midst of the most delightful environs, is widely known on account of its University.

There is no lack there of ancient monuments, some consecrated by tradition, others enhanced by art; suffice is to say

that till the reign of Don João I it was the seat of the royal court and that in one of its temples are the earthly remains of the two first Portuguese Kings, preserved in tombs whose framings are models of the ornate and exquisite workmanship of the 16th century.

The *Old See,* is, among all the cathedrals of Portugal, the one that keeps more endurably impressed the stamp of venerable antiquity, and less altered the primitive architectural style, deserving well on this account the seven plates, which in the album have been devoted to it.

It may be that the attribution of this monument's origin to the period of Arab domination or to a previous one is fabulous; but it is undeniable that its peculiar antique aspect manifests itself in a more complet way than in other similar monuments of the country.

In a like manner to what takes place with the other cathedrals, the reconstruction by the first Portuguese Kings is the primary fact well ascertained respecting the Old See of Coimbra.

To that primitive period, in which the influence of the Bizantine style is manifest, belongs in the frontage the doorway, composed of full-centered and concentric arches, formerly supported on juxtaposited columns, of which the only remains extant are the capitals and the bases.

But the windows, on either side of the doorway, are relatively modern, their opening dating from the end of the 17th century, and the belfry is quite recent, having been somehow absurdly increased during the second quarter of the present century.

In the lateral façade also disagree, though characteristic of a flourishing epoch of the national style of architecture, the arabesques, the medallions and other similar ornaments, that the last architect of Belem came to ingraft in the severe forms of the old temple, coetaneous with the monarchy.

The inside, where the Dutch-tiles, although ancient and of value, conceal almost everywhere the primitive aspect, is divided into nave and two aisles, and preserves still the vestiges of by-gone times.

Such are the three chapels looking towards the transept and whose details are well represented in the plates of the album:

Principal chapel — its carved altar-piece, a capital performance in its style, seems rather a great silver filigree work than a sculpture in wood; it is, according to Count de Rackzinski [1], a fine specimen of the purest Gothic (plate 6th);

Chapel of St. Peter — remarkable for its stone altar-piece, which by the beauty of its relief is easily recognized as belonging to the florid style of architecture of the 16th century (plate 7th);

Chapel of the Holy Sacrament — disposed in circular form, ornamented all around with stone carvings and covered with a comparted vault showing a tendency to the Renaissance style, which supervened in the third quarter of the 16th century.

Turning over the album, we find just at the beginning, next to the panoramic view of the city, one of the finest specimens of the architecture of the 14th century (plate 2nd).

Such is the door of the *Sub-Ripas palace,* the seat of the Telles family, which gave in the person of Dona Leonor a bad wife to King Don Fernando I.

The good taste and excellence of the carvings and of the decoration of this palace called to Count Rackzinski's mind the style of Cellini.

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[1] Prussian ambassador in Portugal about 1844, and author of the works entitled *Les Arts en Portugal* (Paris, 1846) and *Dictionnaire historico-artistique du Portugal* (Paris 1847)

Of an anterior epoch are the remains of the church appertaining to the ancient *monastery of Santa Clara,* founded at the end of the 13th century by Queen Santa Isabel, daughter of Don João III of Aragon, when widow of King Don Diniz of Portugal, and where she took the veil and was interred (plate 26th).

It is a specimen of Gothic art, unfortunately in a bad state of preservation, because the sands of the river Mondego have buried this church, so much so that already in 1649 King João IV was induced on that account to found the new monastery, which crowns the hill opposite Coimbra, forming the subject of four photographs of the album (plates 27th to 30th).

This monastery has nothing remarkable in its exterior, besides the enormous proportions with which it was designed, only one fourth of it having been built, and its picturesque situation commanding the Mondego.

In the interior, apart its classical architecture somewhat heavy, of which give adequate idea the views of the cloister (plates 27th, and 28th), is worthy of attention the sarcophagus, that in the primitive monastery contained the corpse of the foundress and that was afterwards transferred to the choir of the new monastery, where it can be seen, displaying still all the beauty of sculpture enhanced by the antiquity of the workmanship.

What remains now of the body of Queen Santa Isabel, is enshrined in a silver and cristal coffin, represented in one of the photographs (plate 29th).

Speaking of the monuments of Coimbra, we cannot fail to mention two monasteries, one founded in the 13th century by Dona Sancha and the other restored by Dona Theresa, both daughters of King Don Sancho I, and both canonized in the pontificate of Clement XI.

The first is the *monastery of Cellas,* situated in the suburb bearing this same name, and remarkable for its fine *cloister,* reproduced in a photograph of the album (plate 25th).

The other is the *monastery of Lorvão,* at 12 kilometers from the city and close to the village of the same name, between the mountains that rise to the east of Coimbra (plates 31st and 36th).

The monastery of Lorvão, one of the most ancient in Portugal, seeing that it belonged in its commencement to the monks of St .Benedict, who took a share in the glory of the conquest of Coimbra in the year 1064, was given by Dona Theresa, in consequence of the irregular conduct of the occupants, to the nuns of the same order, who kept possession of it till the suppression of the religious communities.

This monastery, when in the possession of the nuns, had many points of contact and in its minutest details the same history than the one of Arouca, situated to the north of it in the Aveiro district and constructed nearly by the same time.

In its exterior it shows little or nothing of the primitive design, according to what we can see from the photograph, in which are exhibited all the characteristics marks of a building of the last century.

In the inside, however, the vestiges of royal munificence in all times are manifest, proving the liberality with which it was endowed.

This is amply shown in the sumptuosity of the choir with its iron grating full of wrought bronze ornaments, its hundred chairs of Brazilian wood and all its sculptured woodwork, which caused this choir to be ranked among the first, if not as the first in Portugal.

And not in a less degree by the two silver tombs rendered more costly by variegated gems, in which repose the mortal remains of the foundresses, and that came in 1713 out of the

hands of the distinguished artist from Oporto J. Carneiro da Silva.

What, however, has given of late much celebrity to Coimbra is its University, especially after the reforms of the Marquis of Pombal.

From all quarters of the Kingdom, from the continent, the colonies and from Brazil too, the students resort to its colleges of theology, law, mathematics, medicine and natural phylosophy.

We see in the first photograph the main building on a commanding situation above the houses of the city, and in another the colleges' court, at one side of which rises the *astronomical observatory* and at the other the *library,* conspicuous also in the panoramatic view of the city (plates 1st and 20th).

In another photograph we see the *botanical garden*, remarkable for the rare and exotic plants it possesses, some of them being large trees of luxuriant vegetation, and for the hothouse, which ranks as the first in the gardens of the whole country (plate 21st.)

In another photograph we see the court and students in a group with their characteristic garb, having to the right the *chemical laboratory* and to the left the *natural history museum,* in whose building are likewise located the colleges of natural science and the anatomical theater (plate 22nd).

Finally, in three photographs we have the inside and outside views of the *library,* a truly sumptuous work, done in the reign of Don João V, whose full-sized portrait we see at the top of the rooms (plates 22nd, 23rd, and 24th).

XI

BRAGA, SANTAREM, EVORA

MONUMENTS AND EDIFICES

1 album (n^er 18) with 32 photographic views: **BRAGA.** — Cathedral, principal façade — The same, exterior of the principal chapel — The same, altar-piece of the Holy Sacrament's chapel — Mansion of the Coimbra family — Mansion of the Paiva family — Bridge do Bico, over the river Cávado — The same, bridge do Bico, over the river Homem. — **LEIRIA.** — Caldas da Rainha (thermal waters), belfry of the mother church — The same, door of the sacristy. — **SANTAREM.** — Christ's monastery, at Thomar, lateral façade of the temple — The same, doorway of the temple — The same, window of the Chapter house — The same, cloister — Graça church, at Santarem, front view — Tomb of Don Duarte de Menezes — Moorish fountain — Church of Gollegã, front view. — **EVORA.** — Cathedral, principal doorway — The same, interior view — Church of San Francisco, exterior view — Graça church, exterior view; University, façade of the Acts house; Temple of Diana; Sertorius aqueduct — Castle of Alvito; House of Garcia de Rezende; Cavalry barracks; San Braz chapel — Cathedral; Loios convent, door of the refectory; Carmo convent, the church's doorway.

BRAGA

We have had already the opportunity, when treating of one of the preceding albums [1], of referring to the monuments and edifices of Braga, and more specially to the cathedral, whose

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[1] See Album n^er 16 — Oporto, Braga — Monuments and Edifices.

photographic views have in the present album a complemental character (plates 1st and 2nd).

The altar-piece of the Holy Sacrament's chapel, which represents in allegory, figured in a grand manner, the Eucharist triumphant, is a most remarkable piece of wood sculpture and of high relief (plate 3rd).

A great number of specimens of much value in this kind of work are to found scattered in Portugal as private property, evidently the spoils of ancient monasteries, attesting the state of improvement in this branch of art.

The *mansion of the Coimbras* and *the mansion of the Paivas* (plates 4th and 5th) are examples of the manner of private-house building in the 16th century, superior to which there are others more characteristic and of more graceful style in the town of Vianna, and we shall soon have occasion to examine another in the city of Evora — Garcia de Rezende's house.

Of the modern bridges do Bico, over the rivers Cávado and Homem, we have spoken already in a special manner when treating of album n^{er} 12 — Road Bridges.

LEIRIA

Belonging still to the Leiria district, whose principal monuments we have described when going over the albums n^{er} 14 and n^{er} 15, is the church of Nossa Senhora do Populo, mother church of the town of Caldas da Rainha, a thermal station most frequented by patients from the capital or by those who resort there for the sake of the enjoyment it affords as a place of summer sojourn [1].

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[1] See album n^{er} 21 — Mineral Waters.

Founded about the end of the 15th century by Queen Dona Leonor, wife of Don João II, and restored in the 18th century by Don João V, this church is represented in the album by the views of its belfry and of the door of the sacristy (plates 9th and 10th).

In the door, around which runs an inscription commemorative of the foundation by Queen Dona Leonor, contributing with its Gothic characters to form the band of arabesques, we see still the misshapen and crude rudiments of the style destined to unfold itself in gracefulness and magnificence during the time of King Don Manuel.

SANTAREM

Belonging to the times of the legendry city, behind the walls of which the Moorish hosts for so long held their ground, is the most beautiful model in that epoch's style, of whose existence in Portugal we have notice.

We mean the *Moorish fountain,* which is to be found near Santarem, and that our album represents in plate 17th.

Among the monuments of the district, the one, which, however, surpasses all others in the historical and artistical points of view, is most certainly *Christ's convent* at Thomar.

Of the architectonic beauties of this monument we cannot but offer a small sample in four photographs, that most luckily up to a certain length, considering their perfection, atone for the paucity of their number (plates 11th to 14th).

The monastery of Thomar was successively in the possession of two famous militar orders — the Knights Templars and the Knights of Christ — whose glorious vestiges remained indelibly impressed in that noble pile.

Whilst in possession of the Templars, who laid the foundation stone of the edifice on the first day of March 1160, it

stood simultaneously as a bulwark of Christian faith and of the nascent monarchy, the Moors sustaining there one of their most signal defeats, which marked the close of their dominion in Portugal.

When occupied by the Knights of Christ, it sheltered them after their struggle in 1335 in behalf of national independence at the castle of Castro Marim in the south of the Kingdom, and had for guardian or *quasi* as Master the Infante Don Henrique before he had undertaken at the Sagres promontory and with the devoted help of that corporation the naval enterprises, which led to the discovery of India and Brazil.

What remains of the first epoch are the ruins of the castle and the church, which King Don Manuel appropriated as principal chapel for a new temple, leaving in it the impress of his time, but without altering the apsis, characteristic of the epoch of foundation, and that we have already pointed out when treating of the Lisbon cathedral and the church of Alcobaça.

To the second period belongs everything, which the wonted magnificence of Don Manuel lavished in the ornamentation of the body of the church, enriching with festoons and fret-work all the lines of the edifice, placing statues in the most prominent places, repeting the *armillary sphere,* the architectonic emblazonment of the monarch, and the *cross,* symbol of the Order of Christ, over the doors and windows, through the whole length of the cornice and crowning its molding.

The doorway, the lateral façade, and the window of the Chapter house unfolding like a flower amidst luxuriant vegetation, are three typical examples of that architecture, expressive of the fortunate days of King Don Manuel's epoch.

Leaving Thomar and coming once more near Santarem, we find at the town of Golleg㠠the *mother church,* whose front shows the Manuelino style divested of all its ornaments, but in all the purity of its graceful lines.

It is unique, or at least the first, being a precious model for the study of the genuine manifestation of the pristine idea destined to evolve the fanciful conceptions embodied in the ornamental stone work of Belem and Thomar, and which at first sight might appear of an anterior and less splendid epoch, if the armillary spheres did not show conspicuously, affording thus a good testimony of the age in which it was erected.

Of the monuments belonging in a strict sense to Santarem, we have in the album a view of the *Graça church,* whose foundation dates from the 14th century (plate 15th), and that Massena's soldiers, in the beginning of the present one, profaned by breaking open the tombs and cooking their meals upon its hallowed stones.

The principal face of this church, in which are most remarkable the doorway, formed by columns disposed in gradations, enriched by capitals adorned with foliage and supporting, two by two, its pointed arch, and the great rose-window shaped out of one single stone and decorated with delicate tracery; is generally considered as the most beautiful piece of architectural work in Santarem.

In the *altar-tomb of Don Duarte de Menezes,* Count de Vianna, erected in the church of San Francisco and presently in the districtal museum at Santarem, we see reappearing in all its splendor the florid Gothic style of architecture, which prevailed during the 16th century (plate 16th).

Don Duarte de Menezes was killed in Africa while fighting to save the life of King Don Affonso V. The body having been cut to pieces by the Moors, his widow was not able to recover but one finger, so that this tomb presents the singular instance of containing merely that small relic of the valiant knight.

EVORA

Evora, the principal city of the provinces beyond the Tagus and one of the most ancient in Portugal, is also the most opulent in bequests of all the peoples who have ruled over the country.

Besides the monuments, the most remarkable of which we shall point out, this city possesses still at present, in spite of the repeated depredations it has suffered, numerous specimens of Dutch-tiles, bronzes, mosaics, *graffiti*, enamels, pictures, inscriptions, books and jewelry of great antiquity and of the highest artistic and historical value.

The vestiges of the Roman epoch are frequent there, being most conspicuous among them the *temple* commonly known as *Diana's* (plate 22nd).

This monument, ascribed to the 2nd or 3rd century and in a state of ruin from immemorial times, is in the style and has the proportions of the *maison carrée* of Nîmes, in France. Length of basement $25^m,18$, breadth $15^m,25$, height $3^m,46$ the height of the columns is $7^m,68$, the greatest diameter a the shaft 1 meter; the intercolumniation ranges from $1^m,3$ to $1^m,68$; the total height of the edifice being near 15 meters [1].

Of the columns of Corinthian order only 14 are standing, 6 at the front, completing it, and 8 in the lateral faces; their shafts, having 12 flutings each, are of granite, their bases and capitals being of Extremoz marble, a town of the province of Alemtejo bearing this name and famous for its quarries.

The *aqueduct* named *of Sertorius* was erected in 1532 by

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[1] Gabriel Pereira — *Estudos Eborenses.*

Don João III, over the ruins of the Roman aqueduct, whose foundation was due to Sertorius, according to the lapidary inscription found among the rubbish by the archeologist André de Rezende, charged by the King with the direction of the construction (plate 22nd).

The *cathedral* shows in the exterior aspect of its ancient portion, notwithstanding the material employed in the construction being another — granite —, so much affinity with the Lisbon cathedral, that most naturally we are led to regard it as belonging to the same epoch (plates 19th, 20th, and 24th).

The doorway formed, like others we have described, by a series of pointed arches supported by slender and juxtaposited columns, their capitals adorned with foliations, calls to mind the one belonging to Alcobaça, also of the same epoch, the great light being, however, accompanied here by pointed-arch openings, the whole encircled by another arch of the same shape.

The principal chapel, most modern, is not in keeping with the remainder of the monument, which is crowned with battlements, distinguishable at once by its character, half religious, half warlike, a character that in general the Portuguese cathedrals still present.

Its construction dates from the 18th century during the reign of Don João V, having been carried out in accordance with the design of the architect Ludovici, to whom had been entrusted the execution of the grand works of the Mafra monastery. This accounts for the magnificence of that portion of the Evora edifice with its profusion of marbles, mosaics, statues, busts and its four monolithic columns of Composite order at the sides of the high-altar.

This principal chapel has the merit likewise of offering an exhibition of the richness and variety of marbles the province possesses, for all the material of this description, with the ex-

ception of *Vert antique*, was procured from the quarries situated in the mountains lying to the north of Evora.

A beautiful specimen worthy of study is that represented in one of the following photographs of the album. It is the double-arched doorway, supported at the middle by a *colonnetta*, of the *Chapter house* and *Refectory* in the cloister of the Loios convent (plate 24th).

We can see well here the evolution of the Manuelino style, which at Evora, more than elsewhere, preserves its Moorish cast, and in this specimen its predominance is evident in the two horse-shoe arches and even in the scutcheon placed above them, which at first sight seems rather to contain an inscription in Arabian characters than the likeness of a fortress.

The *church of San Francisco*, more modern than its convent, the last dating from the 13th century, was rebuilt during the reigns of Don João II and of Don Manuel; the ornamentation is plain, but its proportions are imposing and its aspect austere; the portico advanced and elegantly arched imparts to the whole a peculiar aspect.

It measures 44 meters in length, 13 meters in breadth and 25 meters in height.

The masterly manner, in which its construction was effected, is attested by the nave's vault, poised on walls having only $0^{m},70$ in thickness, without the support even of the smallest buttress.

The *chapel of San Braz*, built in fulfilment of a commemorative vow for the extinction of a pestilence raging in the 15th century, is a sample of the Norman-Gothic style, which gives to it, in a manner, the appearance of a castle (plate 23rd).

Of a somewhat more recent date and of quite another style is the *Graça church*, devoted, as well as the annexed convent, after the extinction of the religious orders, to establishments of different nature (plate 21st).

Both in this one, as well as in the *Carmo church* (plate 24th), and in this last with firmer and more harmonious traits, and again in the old University building (plate 22nd), is evident the influence of the Renaissance architecture.

The *Evora University,* of which the last mentioned plate represents the Acts-house front, was founded in the 16th century by Cardinal King Don Henrique and under the auspices of the Jesuite Company, being suppressed in the end of the 18th century during the reign of King Don José by the inflexible hand of the Marquis de Pombal, in order to give splendor to the Coimbra University and deal another blow to the Company, which the bold minister exterminated.

The *house of Garcia de Rezende,* the illustrious chronicler, with its coupled window and its arches supported by a graceful mullion shaft, edged with tracery work and decorated with interlaced festoons, brings to mind the time of Don Manuel and the like examples we have already pointed out at Vianna do Castello, to the north of the country (plate 23rd).

Respecting the castellated mansion, the seat of the Count-Barons de Alvito, which is well deserving of a special mention, we shall treat of it when describing the following album (plate 23rd).

The building for the *cavalry-barracks* (plate 23rd) shows most evidently by the façade that the architecture is of modern times; it was commenced in 1744 and finished in 1807, being considered one of the best horse-barracks in Portugal.

XII

CASTLES

(Castellos)

1 album (nº 19) with 20 photographic views: Bragança Castle; the same; bridge over the river Cávado; Barcellos Castle and the said bridge — Feira Castle — Leiria Castle — Porto-de-Moz Castle — Obidos Castle — Almorol Castle; the same — Belver Castle. — **CINTRA.** — General view of the town, of the «serra» and of the Pena Castle — Castle of the Moors — General view of the Castle of the Moors, of serra de Cintra, and of the subjacent tableland (on the railway side) — Pena Castle, seen from the east side — The same, from the summit of the Cruz Alta crag — The same, principal entrance — Royal palace of Cintra — The same, entrance — Cintra, market place.

The ancient **castles of Portugal** cannot be regarded as the remains of seigneurial mansions, like those existing in other countries, erected to assure the vassalage rendered by the surrounding inhabitants to the representative of a lordly and privileged family.

Feudalism, which prevailed triumphantly in France, Germany and England, scarcely made itself felt in a vague or indeterminate manner in this remote corner of Europe, where Kings were always jealous of their regale rights and often sought among the people for support against the noble classes.

Nevertheless, the long extent of border line and of sea coast, limiting the narrow strip of land, which forms the Portuguese territory, accounts for the great number of strongholds, that frequently arrest the eye of the traveller, attesting how much in olden times the Portuguese had to struggle in defense of their property and to establish their independence.

The broken nature of the ground suggested and rendered efficient this mode of defense; at one time against the Moors, who firstly, as conquerors, spread themselves nearly all over the Peninsula, and after, as pirates, infested the coast; at another time against the Spaniards, who never could willingly acknowledge the autonomy of their neighbours of the west.

From the *Lapella tower,* rising amid the willow thickets of the left margin of the Minho, down to the *castle of Castro-Marim,* built upon the arid rocks on the right side of the Guadiana; from the *Insua Fort,* standing on the islet, which divides the waters of the Minho, when flowing into the Ocean, to that of *Bugio,* rising in the open sea outside the bar of the Tagus; from *Guimarães castle,* the bulwark of the nascent monarchy, north of the Douro, to the *castle of Extremoz,* the rampart of independence in the broad Alemtejo: the series is as numerous, as it is varied in the form, in the situation and in the different historical incidents connected therewith.

Of this kind of constructions our album presents ten fine specimens, all most beautiful and most characteristic, namely, from north to south: the *castles of Bragança, of Barcellos, of Feira, of Leiria, of Porto-de-Moz, of Obidos, of Almorol, of Belver,* and *of Pena* and *of the Moors in Cintra.*

We have had occasion already of referring to the *tower of Belem*[1], that graceful master-piece of architecture, which the

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[1] See album n^er^ 14 — Lisbon, Leiria—Monuments.

Tagus mirrors in its waters at the entrance of Lisbon, the monument erected at the point of departure for the great discoveries so brilliantly entered upon by Vasco da Gama and continued by Pedro Alvares Cabral.

We have had likewise the opportunity when passing in review the panoramas of Lisbon [1] of mentioning the *castle of St. George,* crowning one of the hills, on which the capital was built.

This is a most ancient castle; according to tradition, it was founded by the Romans at the commencement of the Christian era, and after being successively rebuilt by the Moors, by Don Affonso Henriques and by Don João I, it passed from being the castle of a Moorish Alcaid to be the residence of the Portuguese Kings. At present it is occupied by a presidio and military quarters.

Belonging to the same epoch of primitive construction of the above mentioned citadel, and having experienced, in its first ages, similar vicissitudes, we have the *castle of Almorol,* represented in two photographs, the second of which is undoubtedly one of the finest in our collection (plates 9th and 10th).

It rises picturesquely on the extremity of an islet, pointing up stream, which divides the bed of the Tagus, in the proximity of the Tancos polygon, situated on the right bank, at 115 kilometers distance from Lisbon by rail [2].

This stronghold was built by the Romans, abandoned by the Moors and rebuilt about the middle of the 12th century by Don Gualdim Paes, Master of the Knights Templars, prior to his being engaged in the constructions, which afterwards

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[1] See album n^{er} 13 — Lisbon, monuments and edifices.

[2] See album n^{er} 20 — Practical School of Engineering.

culminated by the erection of the glorious castle and sumptuous monastery of Thomar.

Remarkable alike either for their situation or for the important part they played in the compaigns for the expulsion of the Moors, are the *castles of Leiria and of Porto-de-Moz,* the first crowning a hillock at the meeting of the Liz and Lena streams and the latter resting against a spur of Serra de Minde (plate 6th and 7th)[1].

Not less deserving of mention are: the *Bragança castle,* close to the north-eastern angle of the frontier (plate 1st and 2nd); the *Barcellos castle,* on the right bank of the Cávado (plate 3rd and 4th); the legendary *castle of Feira,* between Oporto and Ovar (plate 5th); the *castle of Obidos,* near the lagoon of the same name and the western railway line, and the *castle of Belver,* commanding the Tagus and the Beira Baixa railway.

Though not comprised in the album, the *castle of Palmella* cannot be passed over without special mention; it rises on the top of an eminence, whose silhouette is characteristic and well defined on the opposite side of Lisbon.

Wrested, like many others, from the Moors by the first Portuguese King, the castle of Palmella was subsequently the seat chosen for the military order of the Knights of San Thiago.

From the top of its walls, now in ruins, the prospect is singularly splendid: afar off on one hand stretches the extensive panorama of Lisbon along the basin of the Tagus, on the other, at the foot of the hill and in front of its ample bay, rises Setubal, the most commercial town of Portugal after Lisbon and Oporto.

The major portion of the castles we have pointed out, and

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[1] See also album n^{er} 15 — Leiria, monuments (last plate).

of those whose construction dates from the same epochs, were formed in what respects to their general plan, by quadrangular towers connected with each other by walls more or less extensive, surmounted by the parapet with crenellated embattlements, like the towers; behind this parapet over the wall ran a walk for communication all around.

In the middle of the space thus enclosed rose the keep, in general of far greater height than the rest of the fortress. It consisted of a square tower crowned with an embattled parapet flanked by projecting turrets, and lighted inside by loopholes, corresponding to each of its floors.

These castles helped more or less to constitute and sustain the kingdom; many are now in ruins or merely guarded by tradition, and, if we call attention to them, it is mainly to show the vestiges of the struggle this small country had to maintain in order to create its nationality, a struggle which had to be renewed in the 17th century, when Portugal recovered its independence after sixty long years of thraldom.

Of quite another kind is the *castle of Alvito,* to which we slightly alluded to when speaking of the corresponding photograph in the preceding album.

It is situated close to the town of the same name in the heart of the Alemtejo, and, though it does not symbolize the feudal institutions, which, in truth, never existed in Portugal, still it offers more or less affinity with those strongholds, that in the countries behind the Pyrenees asserted in so lordly a manner the dominion over the lands in their environs.

From this point of view it is nearly unique. Its traditions, however, are all to the honour of the house of Alvito, to whose representative Don João II about the end of the 15th century gave the charge of building this castle, investing him shortly afterwards in its possession and property.

The elevations as well as the plan of the castle are mos

simple: four wings perpendicular to each other ending at the corners in projecting round towers, higher than the contiguous portions of the edifice, and commanding them; at the center a large open space or court of quadrangular form.

Alike to the kindered castles of former ages, that of Alvito has also its parapet and keep.

The windows show in their ornaments and moldings the different epochs, which succeeded each other during the period of construction.

Cintra, the delightful place of summer resort, which the capital prizes so much, and that all travellers visit, displays, in respect to the kind of constructions we have been examining, specimens of all sorts and in the most perfect state of preservation, thanks to the predilection, which the Portuguese Royal Family have for their residences in that spot.

Its situation on the mountain bearing the same name fitted it for the purpose. The «serra» stretches from Cabo da Roca across the tract of land comprised between the Tagus and the sea and prolongs itself in a north-eastern direction to the «serras» of Albardos and Alqueidão.

The granitic mass of «serra de Cintra», of capricious outline and characterized in the irregularities of its relief by variously shaped blocks crowning the crags and that seem at the point of tumbling down the mountain sides, tempted man in bygone times to erect there the stronghold, the solitary hermitage, and the pleasant country seat.

As vestiges of the first epoch, in which the idea of defense predominated, we have the *castle of the Moors,* with its range of embattled walls, lining the crest of a spur of the «serra» and affording to the beholder the most surprising prospects (plates 13th and 14th).

On the top of one of the loftiest portions of the «serra» we see the ancient convent established there in King Don Manuel's time transformed in the course of our own into the *Pena*[1] *castle* by Don Fernando II, grand-father of the present sovereign.

This royal abode is remarkable alike for the beauty and diversified effects of construction, which seem as if continued from surrounding nature, as for the objects of great value, which lie scattered profusely within its walls by the hand of the *artist-king,* a surname the princely owner was known by already during his lifetime.

Below, at the foot of the northern slope and in the midst of the town, stands the *Royal palace of Cintra,* which, on account of its white-washed walls, of its building without apparent connexion, of its unsightly chimney-shafts, may appear at first sight less interesting, whilst on the contrary, apart its situation, it contains within much that is worth seeing and deserving of attentive notice.

In fact, this palace, that by the shape and decoration of its windows, reminding the Manuelino style, shows it is not a common structure, bears, inside and outside, the impress of past ages, and in a superior degree, more than of any other, the marks of its pristine epoch — the Arab.

Associated to each of the apartments of this palace there is a memorial, a token, of one or another of the Portuguese Kings counting from Don João I, who rebuilt it, but the aspect of the edifice, its internal ordinance, even the names of some of its parts, bring to mind remembrances of the alcazares of Seville and of Granada.

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[1] *Pena* — corruption of *penha,* a lofty crag.

XIII

PRACTICAL SCHOOL OF ENGINEERING

AT TANCOS

(Escola pratica de engenheria em Tancos)

1 album (n^er 20) with 65 photographic views: 1888 — Construction of a trestle bridge on boats — Span bay of a trestle bridge — Schools of electrical telegraphy — Mixed visual signalling station — Laying down of a light trailing line. Crossing of a way — A mine's trench — Inside view of a redoubt. 1889 — Pile driving in the Boa-Vista viaduct — Placing of a trestle in position (Italian system, type B, n^er 2) in the Boa-Vista viaduct — Light field bridge. 1890 — Rendering unserviceable a light field bridge — Light field tension bridge — Light field treble sling bridge, strengthened — Notched bridge — Commencement of erection of an Eiffel's railway bridge — General view of a railway viaduct, composed of one Eiffel's span bay and of two light field span bays. Pontoon bridge prepared to be thrown by conversion — Conversion of a pontoon equipment — Party of telegraph wire-layer erecting a post for a field line — Bivouac at the Hospital's pine wood — Squad equiped for field-work — Squad marching in column formation for work — General view of redoubt for a battalion — Passive shelter at the second parallel — Defensive organization of a portion of the parallel — Construction of a light field suspension bridge. 1891 — Light field suspension bridge — Light field bridge carried on mixed trestles with central fork of one sling — Foot bridge for the passage of infantry in single file — Bivouac shelter — Shooting ground. Practise of firing at a mark, at the fixed distance of 200 meters — Firing of a military mine — Interior organization of a redoubt for a battalion — Passive shelter on the reverse of a parallel — The same on the gorge of a redoubt — Defensive organization of part of a parallel — Railway viaduct, consisting of one Eiffel's span bay and of two light span bays — Cons-

truction of a railway viaduct — Placing of an Eiffel's span bay — Railway viaduct — Light span bay on the right slope — Railway viaduct. Light span bay on the left slope — Raising of a railway viaduct — Removal of Eiffel's span bay — Telephonic car (Lefebvre's matériel) — Intermediate station with two telegraphic apparatuses and a telephone with microphone — Wire-layers and unrollers of permanent line, at work — Boat bridge between the right bank of the Tagus and the Almorol islet — Forming up of a bridge by means of boats in succession — Dismantling of a boat bridge, by bays. 1892 — Light field trestle bridge with movable span bay — The same, the same — Cable suspension bridge — Bivouac shelters — Light field entrenchment in course of construction — Boat bridge with cut — The same, the same — Substitution of a boat — The same — Squad of platelayers at work (railway) — Redoubt in course of construction for a company on war footing — Redoubt for a company on war footing — Progressive double sapping without forms — Visual signalling station with Mangin's heliographer — Mixed signalling station (Mance's heliographer and bandrols) — Cart-station.

The Practical School of Engineering is a military establishment destined to complete the instruction and training of officers and troops of Engineers belonging to the Portuguese army.

It is located in the practice ground or polygon of Tancos, at 110 kilometers distance from Lisbon, on the left bank of the Tagus, and on the railway line of Lisbon to Madrid.

The Tancos school is under a special command, and to it repair annually during a certain time by appointment: the officers of the Engineer's staff whether serving in the War Ministery or employed in the Public Works Department; and two companies of sappers and miners, one of pontoons and the company of railways or of telegraphs belonging to the corps of Engineers, the headquarters of which are at Lisbon. The companies go always with their full completement reinforced.

The officers of the Engineer's staff occupy themselves in reconnaissance, the study of military positions and means of communication, and the ensigns, who have finished their cour-

se in the Military School of Lisbon, are specially employed in surveying and sketching the configuration of the ground, levelling, etc.

The location of the Tancos polygon, close to the confluence of the rivers Zezere and Tagus, an important strategical point, is very well adapted for this kind of works.

In like manner the extent of its grounds (400 hectares), its varied relief, disposition of the environs and so forth, fit it admirably for the course of training, that the companies of Engineers and the platoons of sappers belonging to the Infantry regiments, which are also ordered there every year, have to undergo.

There are permanent works for the operations of attack and defense of fortresses, mines, etc., and with respect to field fortification and other works, they are always designed according to the conditions required by the position selected, and constructed afterwards in accordance with the annual programme.

The pontoon companies go through their exercise on the river Tagus with the pontoon equipment of Thierry's system. The exercise is performed more specially in a width of 70 meters between the right bank and the picturesque islet of Almorol [1], where the old castle is still erect.

Bridges of greater length are thrown from Almorol to the left bank, and there have been instances, in which they were formed up over the whole width of the Tagus with the material of two pontoon equipments (276 meters).

The railway company constructs in the practice ground, for its own instruction, broad and narrow gauge railway lines, renders them unfit for service, and so forth.

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[1] See album n^{er} 19 — Castles.

The constructive works, whether in new lines or for the replacement or repair of those destroyed in the existing lines, are in general of the kind they should be in time of war.

For the service of the whole establishment a narrow gauge line has been laid down starting from the Eastern railway station.

The telegraphic company practices, not only on the permanent lines, but also with its matériel of equipment in laying out and raising field lines in varied circumstances, for which the conditions and surroundings of the polygon are very well fitted.

The views composing album n^{er} 20 are taken as photographical practice by the officers of the corps of Engineers appointed for the purpose, these views representing the principal operations for instruction and training effected in late years by the different companies, their matériel of equipment, etc.

General operations are those in which all companies practice, whatever may be their speciality.

The polygon of Tancos has an excellent shooting-ground for the training of the troops of Engineers and of the Infantry regiments quartered in the proximity of the place.

The Practical School of Engineering was established in this polygon in 1880, the Minister of War ordering the immediate construction of the new buildings required for the accommodation of the School.

It is provided already with an excellent museum of models of the works and matériel of military engineering made by privates and non-commissioned officers under the direction of their superiors.

XIV

MINERAL WATERS

(Aguas mineraes)

1 portfolio (nr 21) with 23 photographic views: 12 of the watering-place of Vidago; 9 of the thermal watering-place of Caldas-da-Rainha; 1 of the thermal establishment of Luso; 1 of the watering-place of Gerez.

1 map of Portugal, showing the situation of the sources of mineral medicinal waters and their distribution with regard to the accommodations afforded by the different establishments.

33 diverse books and brochures, concerning the mineral medicinal waters of Portugal and more particularly those of Chaves, Vidago, Pedras-Salgadas, Caldellas, Gerez, Moledo, Penafiel, San-Jorge, San-Pedro-do-Sul, Felgueira, Luso, Caldas-da-Rainha, Cucos, Cabeço-de-Vide, and Monchique.

Looking over the latest Bradshaw's Guide, we shall most certainly fall short in the appreciation of the richness of Portugal in what respects to mineral waters and will be far from expecting what the map here mentioned discloses.

In fact we see the indication in this map of no less than sixty-two sources of mineral waters adapted to the cure or alleviation of bodily disorders, and whose properties have long since been known. Twenty of these sources are already provided with more or less confortable accommodations, and are

served as far as possible by the common road and railway systems of the country.

It is true, however, that beyond the precincts of the locality or at most of the respective province, the only watering-places known not many years ago were, to the north the Vizella waters and to the south Caldas-da-Rainha.

The development of the enterprises of bathing establishments dates from about fifteen years back at the most. In so short a period and at places where no resources were to be found before, the patient meets with regular hydrotherapic stations, confortable hotels, pleasant promenades, hygienic recreations and most easy means of transport and communication.

A characteristic symptom of this advancement is the literature on the subject, copiously and largely exemplified by the publications we succeeded in collecting and forwarding together with the photographs and the map of mineral waters.

We shall now give the list of the said works, taking the liberty of translating the titles for their more easy and more general comprehension:

Aguas minero-medicinaes de Portugal (mineral medicinal waters of Portugal), by Alfredo L. Lopes pp. 476, Lisbon, 1892;

Sources minero-thermales des aires mésozoïques du Portugal (minero-thermal sources of the mesozoic areas of Portugal), by P. Choffat, pp. 135, with 1 plate, Lisbon, 1893;

Chaves — reconhecimento geo-hydrologico (Chaves — geo-hydrologic survey), by J. M. do Rego Lima, pp. 56, with 1 plate, Lisbon, 1892;

Vidago — memoria sobre estas aguas minero-medicinaes (Vidago — memoir on these minero-medicinal waters), by Alfredo L. Lopes, pp. 77, with wood-cuts, Lisbon, 1893;

Vidago — analyse e outros esclarecimentos sobre estas aguas alcalino-gazosas lithinaes (Vidago — analysis and various ex-

planations concerning these alkaline gazeous lithic waters), pp. 7, Lisbon, 1891;

Vidago — guide with explanatory notes to these alkaline gazeous, lithic and arsenical waters, pp. 23, Lisbon, 1886;

Pedras-Salgadas — estudo physiologico, therapeutico e estatistico d'estas aguas (Pedras-Salgadas — physiologic, therapeutic and statistic investigations on these waters), by A. Teixeira de Sousa, pp. 46, Lisbon, 1892;

Pedras-Salgadas — esclarecimentos sobre as aguas e estabelecimentos da companhia das aguas das Pedras-Salgadas (explanatory notice concerning the waters and the establishments of the Pedras-Salgadas water company), pp. 55 with wood-cuts and 2 maps, Oporto, 1888;

Caldellas, thermas (Caldellas, thermæ), by Julio Cardoso, pp. 52, Oporto, 1891;

Caldellas e suas aguas medicinaes, relatorio (Caldellas, report on Caldellas and its medicinal waters), by E. P. Torres e Almeida, physician attending on the establishment (1892), pp. 14, with 2 maps, Oporto, 1892;

Gerez — historia, hydrologia, medicina d'estas caldas, com um appendice: *Trabalhos experimentaes e chimicos sobre os fluoretos alcalinos* (Gerez — history, hydrology, and medicine of these thermæ, with an appendix: Experimental and chemical investigations on the alkaline fluorides), by Dr. Ricardo Jorge, pp. 202, with 1 map. Oporto, 1888;

Gerez, by Dr. Ricardo Jorge, pp. 220, with illustrations and maps. Oporto, 1891;

Moledo — composição chimica, acção physiologica e effeitos therapeuticos d'estas aguas mineraes (Moledo — chemical composition, physiological action and therapeutic effects of these mineral waters), by DD. M. L. Ferreira Leão, F. A. Alves and Lourenço de Almeida e Azevedo, pp. 155, with 1 plate, Coimbra, 1871;

Penafiel — dissertação sobre as aguas minero-medicinaes d'este concelho (Penafiel — dissertation on the minero-medicinal waters of this township), by A. M. de Sousa Baptista, pp. 84, Oporto, 1884;

S. Jorge (concelho da Feira) — *dissertação sobre estas caldas* (St. George (township of Feira) — dissertation on these thermæ), by A. F. Pinto da Motta, pp. 90 with 1 plate, Oporto, 1890;

S. Pedro do Sul — memoria sobre a villa e caldas d'este nome (San-Pedro-do-Sul — memoir on the town and thermæ of this name), by J. A. de Oliveira Mascarenhas, pp. 27, Vizeu;

Felgueira, aguas mineraes (Felgueira, mineral waters), by J. dos Santos Silva, pp. 36, Coimbra, 1884;

Felgueira — relatorio sobre o estabelecimento thermal d'estas caldas e suas aguas medicinaes (Felgueira — report on the establishment of these thermæ and its medicinal waters), by Dr. J. F. Paes do Amaral, physician to the Company, with medical consideration by DD. L. Torres and M. Bento de Sousa (1891), pp. 38, Lisbon, 1892;

Luso — noticia d'estes banhos. — Apontamentos sobre a sua historia, melhoramentos e administração (Luso — notes concerning the history, improvement and management of these baths), by Dr. A A. da Costa Simões, pp. 192, with two plates, Coimbra, 1857;

Luso — estudos analyticos sobre estas aguas mineraes (Luso — analytical investigations on these mineral waters), by Dr. F. A. Alves, pp. 14, with 1 plate, Coimbra, 1886;

Luso — estatutos e regulamentos da sociedade constituida para o melhoramento d'estes banhos (Luso — statutes and regulations of the society formed for the improvement of these baths), pp. 34, Coimbra, 1886;

Luso — relatorio e contas da sociedade em 1889 (Luso — re-

port and statement of accounts of the society, in 1889), pp. 15, Coimbra, 1890;

Luso — the same in 1890, pp. 19, Coimbra, 1891;

Luso — the same in 1891, pp. 19, Coimbra, 1892;

Cabo Mondego, aguas sulphurosas (Cabo Mondego, sulphurous waters), by Gaspar Gomes, extract from the Journal of the Lisbon Academy of Science, n^er^ XLV, July, 1887, pp. 10, with a map;

Caldas da Rainha — memoria sobre as aguas thermaes d'estas caldas (Caldas-da-Rainha — memoir on the thermal waters of these baths), by J. dos Santos Silva, pp. 50, Coimbra, 1876;

Caldas da Rainha — a proposito da estatistica dos doentes em 1889 (Caldas-da-Rainha — apropos of the statistics respecting the patients in the year 1889), by J. F. de Andrade Rebello, physician and inspector of the establishment, pp. 14, with 1 table, Alcobaça, 1890;

Caldas da Rainha — the same, with respect to the year 1890, by J. V. Carril Barbosa, pp. 7, with 1 table, Alcobaça, 1891;

Caldas da Rainha — the same, with respect to the year 1872, by H. dos Santos Pinto, inspecting physician, pp. 10, with 1 table, Alcobaça, 1893;

Cucos — guia d'estas aguas minero-medicinaes, proximas de Torres Vedras (Cucos — guide to these minero-medicinal waters in the neighbourhood of Torres-Vedras, pp. 168, with 2 plates, Lisbon, 1892;

Cabeço de Vide — banhos sulpho-alcalinos (Cabeço-de-Vide — sulpho-alcaline baths), pp. 23, Oporto, 1891;

Monchique — mappa estatistico d'este estabelecimento thermal (propriedade do estado) (Monchique — statistical table concerning this thermal establishment, the State's property), 1892.

The date and the contents of these publications show well

how recent has been the interest taken by men of science in the matter, and also the favour of capitalists towards this part of the natural resources of a country that in this respect ranks most undoubtedly as one of the first.

Although the question had been already taken into consideration in 1860 and had led to the presentation at different times of four proposals in Parliament, it is quite of recent data the special attention paid by Government to this subject of so important a bearing, either in the philanthropic or the financial point of view.

None of the said proposals, however, came to the point of even entering in discussion, and it was only in 1892 that the dispositions regulating the turning to profit of the sources of mineral medicinal waters and the keeping of the annexed establishments were definitively sanctioned by royal decree of the 30th September, 1892.

The thermal establishments of *Caldas-da-Rainha,* lying at 109 kilometers distance to the north of Lisbon, and that of *Monchique,* on the southern slope of the «serra» having the same name, which divides the provinces of Alemtejo and Algarve; are both State's property.

The first of these establishments is most ancient, its foundation stone having been laid in 1488 by Queen Dona Leonor, wife of Don João II, who had tried on herself the efficacy of these thermal baths, which she rendered distinguished by bestowing on them the qualification of her exalted rank (Queen's Baths).

The Portuguese Royal Family passes still part of the hot season at that place, where the coolness of the sea breeze is always felt, and a few months since, in March, King Don Carlos inaugurated the new hospital of Santo Isidoro, arranged in accordance with all the requirements of modern science.

Besides the two bathing establishments above mentioned,

all the others are turned to profit by joint stock companies or by the municipalities, the following, coming from north to south, being distinguished for their accommodations and other conditions:

Vidago, in the township of Chaves, district of Villa-Real and province of Traz-os-Montes; watering-place served by the Douro railway up to Regua station and afterwards by the macadamized road; it is represented by a plate in the twelve photographs belonging to the collection exhibited.

According to the opinion of the distinguished Portuguese chemist Dr. A. V. Lourenço, not long since deceased, the alkaline waters of Vidago can compete with those of Vichy;

Pedras-Salgadas, in the township of Villa-Pouca-de-Aguiar, district of Villa-Real and province of Traz-os-Montes; in conditions similar to those of Vidago.

The arsenical waters from the spring called «do Penedo» are comparable to those of Plombières;

Gerez, in the township of Bouro, district of Braga, province of Minho, on the slope of the «serra» bearing the same name; a watering-place served by the Minho railway up to Braga station and from thence by the common highway, laid, as well as the railway, through the most delightful and most populous region in the country.

The thermal waters of Gerez, in whose composition chemistry could not for a long time discover any special principle worth observing, and that now shows persistently a fluor dose, were always held in great repute in consequence of their remarkable therapeutic properties and they are anxiously sought for by hepatic patients;

Vizella, in the township of Guimarães, district of Braga; served by the Minho railway and by the small narrow gauge line, called «de Guimarães».

This is a most ancient establishment, frequented by persons

that seek relief in its waters of sulphurous nature for rheumatic and herpetic complaints.

Its situation is one of the most pleasant in the heart of the shady woodlands of Minho;

Felgueira, in the Vizeu district and province of Beira; at short distance from the railway station of Cannas-de-Senhorim in the Beira Alta line, near the banks of the upper Mondego and in communication by means of good roads with the principal places of the province and with Serra da Estrella, which affords field for the most varied and interesting excursions.

Thermal establishment lately enlarged, but very well known and of repute already, due chiefly to the cure of herpetic and rheumatic complaints and of affections in the respiratory organs. In respect to the last, the distinguished Portuguese practitioner Dr. M. Bento de Sousa puts the Felgueira springs on a par with the most famous of Cauterets;

Luso, in the vicinity of Coimbra, having a station on the Beira Alta railway.

The therapeutic properties of these waters are not of the highest order, but as sanitary station and place of summer resort Luso ranks as the first, on account of the proximity of Serra do Bussaco, so notable for its forest and landscapes;

Cucos, at about 2 kilometers distance from the town of Torres-Vedras and at 3 from the town of Runa, in the district of Lisbon and province of Extremadura, nearly in sight of the Western railway station.

Its waters have been since long of repute on account of their efficacy in the treatment of the gout, but the attendance of patients was very limited for want of proper accommodations. The earnest endeavour of a private citizen has put, however, an end to this precarious situation, for he succeeded in raising there an establishment from the very foundations,

which will be opened for the first time in the present bathing season.

Its location on the banks of the meandering river Sizandro is most delightful;

Estoril, township of Cascaes, district of Lisbon; in the most picturesque situation by the sea-side and with excellent means of communication by the railway, which runs from Lisbon along the right bank of the Tagus.

It has at the same time a splendid sea bathing beach, and one of the thermal springs is in such close proximity of the sea, that often, and more specially in winter, its waters encroach on the establishment.

The joint stock company formed for the improvement of Estoril attempt disputing to Nice its fame as a winter station.

XV

HARBOUR WORKS IN THE AZORES

Albums n^os^ 22 and n^os^ 23

The **Azores** are situated in the Atlantic Ocean opposite the mainland of Portugal, at 250 leagues from Cape da Roca, between 36° 57′ and 39° 41′ north latitude and 15° 50′ and 22° 10′ west longitude according to the meridian of Lisbon.

They consist of three groups of islands: San-Miguel and Santa-Maria, to the east; Fayal, Terceira, Graciosa, San-Jorge and Pico, in the center; Flores and Corvo, to the west.

Owing their existence to volcanic action, the Azores display a well marked geologic character, which is strikingly exemplified even in the plates of the present albums.

The craters of extinct volcanoes are a frequent feature of their outline; the island of Pico, for instance, the most characteristic and most mountainous of the whole group, whilst it shows at the highest point, 2:322 meters in altitude, the dazzling whiteness of the snow, denounces the latent volcano by the smoke emitted from its bowels.

Abundant sources of thermal waters; jets of boiling water spouting from the bosom of the earth; lakes which the first colonists fancifully designated by the expressive name of «Cal-

deiras» (caldrons); cavities extensive and ramified, emitting loud sounds and clouds of vapour, showing frequent vestiges of sulphurous emanations, as at the «Furnas» of Terceira and San-Miguel: are as many tokens of igneous agency in the formation of the ground of this archipelago.

Since its discovery, begun in 1432 by that of Santa-Maria, up to the present, this agency has not cessed to be at play; earthquakes have succeeded each other in the course of centuries and the eruptions accompanied by elevations, which disappeared nearly as rapidly as they had occurred, are of our own times.

Most important towns and villages have been destroyed by earthquakes, and the molten lava flowing over the surrounding country has carried far the devastation.

But, side by side with these vestiges of repeated subterraneous commotions and of blighting discharges of heated rock matter over the face of the land, it seems as if nature had taken pleasure in disposing the most delightful sites, in fostering the most exuberant vegetation and the growth of most delicious fruits and of most productive crops.

The growing of the *sugar-cane* and the culture of the *woad* prospered there with a successive and wide development, and, if they have decayed, it is mainly due to circumstances foreign to the local elements.

The *vine* has likewise grown very well and it still yields at San-Miguel, Pico, Graciosa, San-Jorge and Terceira much esteemed vintages, of the light Bordeaux kind [1].

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[1] The white wines produced formerly in the Azores, among which the one grown at Pico was held in high estimation, are of scarce production at Pico and Graciosa after the ravages of the *oidium*. The vines, whose yield is lately increasing there, are stocked with the American sort called Elizabeth. They give a light red wine, a little acid and with much bouquet, being distinguishable the types from Terceira and Pico.

The diseases of which this plant suffers, are due to general causes, observed every where. The principal wine-growers of the isles combat their progress by reitereted applications of the remedies most in vogue, and principally by means of the insertion of American cions in the old stocks.

Another production, evincing in a like manner the fertility of the soil, is that of *bread-stuffs,* principally of wheat and maize, the former preferred at Terceira and the latter at San-Miguel, both being raised in a scale that exceeds home consumption, so much so that grain is largely exported to the continent.

The *pine-apples* and the *oranges* of the Azores are held in high esteem, as well in Portugal, as in England and even in America; only the making of the boxes to pack the second of these fruits constitutes a branch of local business occupying a great number of hands.

The growing outlet, which the *dairy products* are finding on the continent, for instance the cheese from Pico, a speciality which has already gained a name, shows most evidently the importance and bids fair to the future prospects of cattle breding in the Azores.

We will mention still the *sweet potato,* which grows with great vigor in the soil of these isles and which is now a source of profit for its application to the manufacture of spirits, so much so, that the laying of the duty on this article has been the subject of special consideration from the Legislature amidst the conflict of interests, which has sprung up, chiefly on account of the variety of materials used in the distillery business.

Such remarkable capabilities of the soil imposed themselves to the solicitude of Government, and from hence the successive harbour works entered upon at Ponta-Delgada and at Horta, that we are going just now to occupy ourselves of.

THE PONTA-DELGADA HARBOUR

(Porto de Ponta Delgada)

IN THE ISLAND OF SAN-MIGUEL

1 album (nº 22) with 9 photographic views: — **PONTA-DELGADA.** — Anterior and oblique view of the central part of the city — Anterior and normal view of the same — The harbour, road-stead — Posterior view of the city and harbour — The port, anchorage ground close to the mole's quay, in use for the purposes of the harbour works — The same, setting in place of the artificial blocks by means of the *Titan,* for the mole's extension and for the quay's revetment — The eastern parts of the city and harbour seen from the extremity of the mole in course of construction — Quarries of Santa Clara, instantaneous view of the sinking down of a portion of the works in the said quarries — The same, general view of the work-yard.

The **Island of San-Miguel** is considered the richest and the most considerable of the Azores.

Its mineral medicinal waters, enjoying a wide spread fame, are to be found in the interesting region of the «Furnas», in which the characteristic features of a volcanic land are more marked and where the comforts and the accommodations afforded have since long attracted both the invalid and the tourist.

Cultivated on a larger scale than any other island of the archipelago, San-Miguel stood in great need of the improve

ment and the enlargement of the harbour of Ponta-Delgada as an indispensable element for its prosperity.

The exportation of oranges, increasing already in the first half of the present century at such rate as to pass from 40:000 to 261:000 boxes, was of itself sufficient to determine the construction of an harbour of refuge at Ponta-Delgada, according to the authority granted to Government by the law dated the 9th August, 1860.

In fact this was the most eligible point for the carrying out of so momentuous an improvement.

The Island of San-Miguel, like that of Madeira, extends in the east and west direction, and the Ponta-Delgada harbour, spreading out on the southern coast and sheltered consequently from the northern winds by the range of mountains stretching in like manner from east to west, had been always the principal sea port and the center of all the island's trade.

The **city of Ponta-Delgada**, situated between 37° 44′ north latitude and 16° 37′ west longitude according to the meridian of Lisbon, is built all around the bottom of the harbour, and as much by the number of its inhabitants as for the proportions of its edifices, and moreover by the flourishing condition of its trade, maintains deservedly the rank of chief city of the archipelago.

The photographs forming the present album display well the principal features of the city, and above all its delightful situation on the sea side, encircled by gardens at the foot of hills of diversified outline and carefully cultivated up to considerable heights.

The first plate embraces the city from the modern *Corpo-Santo Market,* seen to the left near the quay, to the Custom-house building, the tower of the *mother church* rising conspicuously above the surrounding house tops and further off the one belonging to the *Municipal palace.*

The second plate shows the front of the city, nearly between the same limits and affords a better view of the principal church's belfry and of the three centered triumphal arch, close to it on the right, erected during the time of the Spanish dominion; immediately to the left, but further off, we see the *Jesuit college,* and, more to the left still, at a greater distance, surrounded by trees, rises the *palace of Count Jacome Correia,* a princely mansion that might grace the environs of Genoa or of Naples.

The third plate represents that portion of the city, which lies nearest to the mole's beginning, between the strand of San Francisco and the *San-Miguel penitentiary,* that the masts of the shipping do not allow to see well.

In this direction, that is, more towards the side of the mole's connection, are the points of view, which in the sixth and seventh plates embrace the city, and prominent, among other buildings, from left to right, are seen the *church of San-Francisco,* and nearly contiguous to it the *church of the Misericordia* and the belvedere of the *Esperança convent.*

In the whole of these plates, and in the fourth, taken from the hill side commanding the harbour, stand out well beyond the line of surface in the environs of the city the pyramidal tops of the *Araucarias,* marking the sites of the gardens, which the inhabitants prize so much; the dark clusters of tree growth, representing the famous orange-groves, and afar off, on the hill sides, the dusky lines, often repeated and parallel to each other, which are as many fences or boundaries of the vine-growing lands.

As best seen in the fourth plate, the artificial harbour is situated opposite the city, being formed by a mole or breakwater advancing in an oblique line from its western limit and running afterwards in a parallel direction to the coast.

The solemn inauguration of the works took place on the

30th Setember, 1860, but the first tons of loose ruble stone were only laid down for the mole's construction on the 28th October of the following year.

Commenced under the responsibility of Sir John Rennie, the well known hydraulic engineer, and in accordance with the project of his coadjutor Mr. Tucker, the works passed in 1866 to be under the direction of Portuguese engineers, and so they have continued up to the present.

They ought to be concluded within three years.

The first designs consisted of two moles, perpendicularly connected with the central part of the city; the consideration, however, of the natural shelter afforded by Ponta da Galera, projecting eastwardly, determined the relinquishment of the idea of constructing a mole on this side, and the advisibility of adjusting the plan of the mole on the other side with the track lines of the Santa Clara quarries, situated to the east of the city, suggested and led to the adoption of the plan of removing westward the point of the mole's connection and of tracing the first alignment in a sharp angle with the general direction of the city's marginal streets.

In this way subsisted the design of one single mole in two alignments: the first one, to which we have already made reference, and the second, parallel to the coast, commencing at a distance, which varied according to the subsequent designs.

This second alignment was not carried out, the portions commenced being successively abandoned and the mole was prolonged in another alignment forming a very open angle with the first and ending at the circular head of the mole.

This one measures, therefore, according to the definitive project 1:200 meters in length, divided as follows:

Adjustment at the commencement:	
Straight	19m,76
Curved (radius = 1:951m,60)	199m,83
Mole:	
1st straight	535m,56
1st curved (radius = 106m,37)	58m,48
2nd straight	371m,37
Molehead	15m,00
Total	1:200m,00

There have been many modifications made both in the transverse profile and in the ground-plan, in accordance with the systems and processes of construction adopted, to which was requisite to subject the conclusion of the works.

The principal modification consisted in the restriction of the transverse section, whose width chiefly in consequence of the spreading and longitudinal displacement of the stones had assumed unusual proportions, causing the formation of shoals in the very midst of the harbour.

At the beginning, the mole, which was nothing but a range of stones of every dimension, but of limited size, was constructed by means of a wide wooden bridge, carried always in advance of the works, and serving for the conveyance of the stones till they were thrown upon the mole.

The Portuguese engineers abandoned this process and adopted with the best success the conveyance by water, the wagons loaded with stone reaching only as far as the beginning of the quay, the load being then transferred into lighters, as seen in plate 5th of the album.

By following this process, by the employment of stones of greater bulk and of artificial blocks in the revetment on the harbour's side, the summit of the mole was reduced and the talus narrowed.

The section being thus reduced throughout the mole's extension, the constructors realized an important reduction of cost and afforded at the same time more stability to the works.

The central core of less voluminous rubble stone was kept, but was covered on its upper portion and on the seaward side by courses of artificial blocks with increasing weight from 2 to 8 tons and upwards, the slopes diminishing successively on this side from 1,5 to 3, and to 8 of base by 1 of height.

Into the upper bed of this enrockment, established at low-tide mark, is fitted the sheltering wall, having $6^m,50$ of thickness at the base, 5 meters at the summit and rising to the height of 10 meters, besides the parapet, which measures $1^m,20$ in height.

At 1 meter above high-tide mark is levelled in 20 meters of width the terreplein of the quay, whish accompanies the mole on the inside and is sustained by superposed artificial blocks set vertically up to low-tide level, and from that line upwards by a masonry wall with the competent batter, to the total height of 8 meters.

Such is the type of the transverse profile adopted, pursuantly with the preceding works done by the English engineers.

The *Santa-Clara quarries* (plates 7th and 8th) are at no more than 1 kilometer's distance from the commencement of the mole and have sufficed for the purposes of its construction and repair, notwithstanding the successive extensions and the gaps produced in consequence of the storms, which are of proverbial violence on the Azorean sea coast.

The rock is basalt arranged in masses intercalated with layers of loose matters, and these last, when removed by digging, allow of the easy extraction, without the help of gun-powder, and solely by means of the natural act of sinking

[illegible] of stones of very large bulk, which has ren-

dered unnecessary the employment of artificial blocks to protect the seaward slope of the mole, the blocks having been manufactured solely to form the substructure of the quay wall.

The weight of the natural quarry blocks has reached 18 tons and 20 tons at the utmost, the 8-ton blocks being common. The density of basalt contributes in a considerable manner to this result.

The two last photographs give a most adequate idea of the general arrangement of the work-yard and of the mode of working the Santa-Clara quarries.

The hoisting engines used for raising and removing the stones, represented by the most powerful in the last but one photograph, have utmost strengths, which vary from 5 tons to 22 tons each. For the conveyance of materials the works are provided with four locomotive engines.

The greatest approximate dimensions of the artificial blocks are :

$$4^{m},5 \times 2^{m},0 \times 1^{m},7 = 15^{cm},3$$

and weigh about 40 tons.

The *Titan,* to hoist them, seen in two of the photographs (plates 4th and 6th), has the maximum power of 45 tons, measuring 55 meters between the axis and the extremity of the arm or jib.

This engine, as well as the one employed in the Funchal harbour works, was calculated by M. *T. Seyrig;* it was constructed in the workshops of *Société de Willebroeck* (Belgium).

The artificial blocks are of rubble stone bedded, either with Theil lime (350^{kg} for $1^{cm},0$ of sand), or with Portland cement (1 part of cement for 3 of sand).

The rubble work for the quay and sheltering walls is bedded

with pozzolana of the same island of San-Miguel (much used in hydraulic works on the continent) mixed with slaked fat lime in the proportion of 4 parts to 1, without the addition of sand.

The works of the mole's advancement have reached already the last straight alignment, distant 50 meters from the site marked out for the setting up of the completing circular head.

The length of quay line constructed at the mole with increasing depths from 2 to 6 meters at extreme low-water mark in spring-tides measures 175^{m},35; with constant depth of 6 meters, 314^{m},65; in course of construction with 8 meters depth in the last portion, 230 meters. Aggregate length, 720 meters.

When the mole is finished, the sheltered area will be of 363:200 square meters, 204:300 square meters being available for anchorage ground and manœuvering of vessels.

In this area we may reckon on 74:000 square meters with depths from 1^{m},50 to 12 meters in extreme low-water for roadstead of 40 ships of 1:000 tons burden, and on 160:300 square meters with depths ranging from 12 to 20 meters for ships of superior burden.

We shall mention here that the maximum amplitude of the tide attained on the 10th February, 1868, was 2^{m},27, the minimum on the 27th June, 1867, being 0^{m},47.

The works in course of completement at the harbour of Ponta-Delgada constituted the subject of a general contract to the amount of 1:200:000$000 réis (£ 266:666).

General contractors: Messrs. *F. Combemale* and *J. Michelon,* joint partners in the general contract for the Funchal mole in the Island of Madeira.

Engineers who have been at the head of the works since 1866: srs. *R. Julio Ferraz, A. Kopke de Barbosa Ayala* and *M. Machado de Faria e Maia,* present director of the dis-

trict's public works and charged with the supervision in the execution of the contract.

Engineer to whom the actual general contractors have confided the chief direction of the construction : M. *Darteyre.*

THE HORTA HARBOUR

(Porto da Horta)

1 album (nº 23) with 2 lithographic designs: Map of the 3 islands of Fayal, Pico and San-Jorge, plan and profile of the project (in course of execution) of the Horta harbour — 6 plans relating to the first preliminary projects for the improvements of the Horta harbour.

And 7 photographic views: Breakwater or mole, in course of construction — Embankment leading to the breakwater, also in construction — Artificial blocks'yard — View of a part of the quarries — Railways for the service of the quarries and engine house — Depot of locomotives and Director's office — Workshops.

If the construction of the artificial harbour at Ponta-Delgada imposed itself to the administration on account of the importance of the Island of San-Miguel and of the trade of that city, the construction of a similar one at the Island of Fayal close to Cidade da Horta was an inevitable consequence of the absolute and relative excellency of situation of this island and its principal town.

The **Island of Fayal** belongs to the central group of the Azores, and by its approximate equal distance from Europe, Africa and America offers great advantage to navigation as vessels bound to any point of these three continents may put in or touch at its port when crossing the Atlantic.

Cidade da Horta lies between 38° 33′ north latitude and 19° 21′ west longitude from Lisbon, at the bottom of a bay

facing the southeast, being sheltered on the northern side by Ponta da Espalamaca, on the western by Monte-Carneiro, on whose slope the town is built, and on the southern side by the peninsula formed by the Guia mountain and by the isthmus of Monte-Queimado.

In addition to this shelter of its own, there is the protection afforded in the open sea by the islands of San-Jorge and of Pico, both mountainous, chiefly the last one, whose highest point attains 2:322 meters of altitude and whose broader extremity lies opposite, at about 7 kilometers distance from Fayal (1st lithograph).

Besides this as outliers of Monte-Queimado and disposed in a sense perpendicular to the coast, there was a range of reefs more or less irregular, some at the surface, others below it, offering support to the works that might be made for the purpose of completing the shelter of the harbour.

It was indeed at the foot of that hill and upon the «Pedras Queimadas» (burnt rocks), that the breakwater or mole of the artificial harbour was firmly implanted and found support, the work remaining thus composed of:

First straight alignment, determined by the advantageous position of the reefs, which was turned to good account	516^{m},00
Junction curve	59^{m},23
Second straight alignment determined by the condition of completement of shelter	132^{m},30
Diameter of the mole head	37^{m},10
Total	744^{m},63

The area sheltered has 215:000 square meters, available only for about 80 vessels of all sizes on account of the res-

triction imposed by the surf, which does not allow of safe anchorage in a breadth of 50 meters around the coast.

The mole's transverse section has much similarity with the one adopted for the mole of Ponta-Delgada, partaking of the Marseilles and Holyhead types (1st lithograph).

Below runs a mound of trapezoidal section, with slopes of 45°, formed of lumped rubble stone of first sort, the maximum weight of each of the stones being 2 tons.

Upon the summit of this mound and on its seaward slope, there is another layer of stones, thrown likewise in a lump, but of second sort, weighing upwards of 2 tons each.

On the seaward side of the layer down to the depth of 6 meters below low-water level, limit ascribed to the agitation of the waves, there is an incavation 5 meters wide to base the revetment composed of artificial blocks, which comes up above high-tide mark and near to the summit, ending in an adjusting talus of about $2^{m},50$ of base by 1 meter of height.

In a like manner, on the land side and at 7 meters depth below low-tide and nearly in the same width, is graded the bed for the quay wall's substructure, that rests on the core of loose rubble stone.

This substructure is formed of artificial blocks laid horizontally in regular courses with alternate vertical joints and with an upright facing on the outside.

Upon the substructure rises the quay wall, properly speaking, of common masonry work, up to 1 meter above the line of spring tides, with the exterior batter of 5 per cent and vertical inside facing forming steps $0^{m},2$ in every meter, the thickness at the top being 2 meters.

The sheltering wall set in between the layer of artificial blocks and the mole's terreplein, begins at low-water level and rises to the height of $6^{m},50$.

It has on the inside a vertical facing, a thickness at the

top of 3 meters, and on the outside a batter of 10 per cent in its salient portion, which is 4 meters in height, and a batter of 15 per cent in the portion engaged.

Upon the sheltering wall and on the side looking seaward runs the parapet, which is 1 meter in height and $0^{m},80$ in thickness.

The width of the mole's terreplein between the sheltering wall and the edge of the quay line measures $16^{m},40$.

The quarries represented in one of the photographs of the present album (plate 4th) are of basaltic stone, like those of Ponta-Delgada harbour works, being situated at the mean approximate distance of 2:000 meters from the mole.

The artificial blocks measure

$$4^{m},0 \times 2^{m},0 \times 1^{m},75 = 14^{cm},0$$

being made of rubble stone bedded in mortar: French hydraulic lime from Theil mixed with sand in the proportion of 350 kilograms of lime to 1 cubic meter of sand. Plate 3rd represents the stone-yard, where these blocks are deposited.

In the rubble work for the quay and sheltering walls is used the pozzolana of the same island of Fayal, which differs much from the pozzolana of San-Miguel, which is the only one known on the continent; in the mixture pozzolana, slaked fat lime, and sand enter in equal proportions.

To lift and convey the artificial blocks is employed the engine called *Samson,* a sort of portable stage capable of raising a 30 tons weight; to lay the blocks for the foundation of the quay wall and revetment of the mole there is the *Titan* of equal power and with a 25 meters range.

The first is of English make; the latter was constructed, according to the Ponta-Delgada pattern, at the workshops of *Société de Willebroeck.* Of the $744^{m},63$ of the projected mole,

480 meters are already built, the works being pushed on most vigorously in the remainder.

Besides the quay line, that the mole will afford in its whole extent with 7 meters depth at low-water in spring-tides for the length of 500 meters, the project embraces likewise the marginal quays of the town, between the slope of Monte-Queimado and the Custom-house with the aggregate length of nearly 500 meters and depths of water ranging from 2 to 4 meters, according to the above mentioned level.

We must observe here that the greatest amplitude of tides registered is of $1^m,50$.

The works in course of execution at the Horta harbour constitute the subject of a general contract for the amount of 1.100:000$000 réis (£ 244:444).

The total cost of the projected harbour works, including the marginal quay lines of the city and the ancillary works, such as a slip for the repair of vessels carrying up to 300 tons burden, will amount, according the estimate, to 1.875:000$000 réis (£ 416:666).

The term fixed for completement of the whole works is three years.

The general contract for the works at present in course of construction was entered into by the *Companhia Nacional de construcções* (National constructing Company), the technical director of which is sr. *D. Xavier Cohen,* major of Engineers.

Manager of the works on the part of the said Company: sr. *C. Moniz de Vasconcellos,* conductor of public works.

Designer of the primitive plan elaborated by order of Government: Colonel *Tiberio Augusto Blanc,* deceased; designer of the definitive project and the first to commence the works, under the Government's own management, on the 25th of March, 1876: sr. *A. Kopke de Barbosa Ayalla,* director simultaneously of the Ponta-Delgada harbour works.

Officer charged with the supervision of the works carried out by the contractors: sr. *F. Xavier de Mesquita,* conductor of 1st class serving as director of public works in the Horta district.

XVI

ISLAND OF MADEIRA

(Ilha da Madeira)

1 album (n^er^ 24) with 12 photographic views: Water-course for irrigation of the parishes of Caniço, San-Gonçalo and Santa-Maria-Maior, Fayal section — Panoramic view of Rabaçal — New «levada» (water-course) of Rabaçal, Levadinhas tunnel (northern entrance) — The same, the same (southern entrance) — Old levada of Rabaçal, Ribeira (stream) do Risco — The same, Risco water-course — New water-course of Rabaçal, Levada «das vinte e cinco fontes» (of the 25 fountains) — Cidrão bridge on the royal road n^er^ 27, from Funchal to Boa-Ventura — The so-called «Monumental bridge» on the royal road n^er^ 23 — Royal road n^er^ 24 from Funchal to Sant'Anna — Royal road n^er^ 23 along the sea coast — Water-course known by «Ribeira da Boa-Ventura».

A manuscript paper concerning the water-courses.

The **island of Madeira**, together with that of Porto-Santo and the Desertas, constitute the group bearing the name of the first, which lies in the Atlantic Ocean between 32°25′ and 33° 7′ north latitude, and 7° 30′ and 8° 7′ west longitude, according to the meridian of Lisbon.

Having 65 kilometers of length from east to west, and 20 of greatest width, its area measures about 500 square kilometers.

Every body knows, at least by hearsay, that the climate of Madeira is so mild and equable, that those privileged by fortune and looking out for enjoyment resort to that favoured spot for a winter sojourn, as well as those to whom medical science has recommended it as a precious resource for pulmonary disease.

Mean temperature 20°; barometric pressure 762 $^{m}/_{m}$; mean humidity of the air 70 %; days of brilliant sunshine 170, cloudy 110, rainy 85; death rate 29 per 1:000: are observations and data recorded in books and that proclaim Madeira as «the sanatorium for phtisical patients».

But what very few of those who never set their feet there or ever passed opposite this delightful island, know or duly appreciate, is the treasure of picturesque beauties, of which every description would be inadequate, and of which photography only, enhanced by the skill and artistic taste of the operator, as exemplified in the plates of the present album, can afford an idea.

In the capricious indentation of the mountain crests, some of which terminate in a pointed summit and rise of a sudden in so restricted a space to heights approaching 2:000 meters and even more, as at the loftiest point of Pico-Ruivo; in the wide expanse of the mountain sides, scarped on the northern face and less precipitous on the opposite one, covered always with a luxuriant and varied vegetation; in the circuit of the sea shore, either commanded by bold cliffs or disposed with a terraced or step-like appearance; we see the landscapes succeeding each other, at one time diversified and delightful.

On a soil distinguished by such varied features and clothed by an exuberant vegetation, of cactus with their fleshy stems, of lofty palm-trees, of bananas in full efflorescency or fructification, crop out rocky masses accusing their volcanic origin,

such as the trachytes and basalts, whose structure, hue and texture impart to this isle, as well as to the others in its vicinity, a most characteristic aspect.

It is a known, fact that at Madeira agriculture has been cruelly tried by differents scourges, that one culture has succeeded to another, as promptly embraced with eagerness as discarded soon after by the force of unexpected circumstances; that the hard-working islander has no rest and has endeavoured constantly to render his fields productive by dint of new agricultural and industrial attempts.

Much ignored, however, is the importance of the irrigating works undertaken in the island since the 17th century, and continued in the present one with much zeal, either by private enterprise, or by the help or the impulse of the State.

The plates of this album will serve also to display and divulge the value of so momentous a work, and the efforts it has cost, showing us their principal points (plates 2nd to 7th, and 12th).

The extensive water-courses, some of which appear as lines cut by a graving tool on the face of the steep rock (plate 1st), and always across dense tree growth; the subterraneous passages, which at points are as wide and high as those of a railway; abstracting of course the inequalities of the ground, call to mind the fecundating works, that Arab civilization introduced and developed in the Spanish provinces of Murcia and Valencia bordering on the Mediterranean.

The proximity of Africa and the date of commencement of the works, going as far back as the reign of Philip II, lead us to believe in a similar origin, directly or indirectly.

The groups of «levadas» or water-courses for irrigation are two in number.

The first is mainly composed of the two water-courses established at different levels, with the purpose of conveying

the waters from the northern slopes of the island to the slopes facing the south: the *old* and the *new levada of Rabaçal.*

The *old levada of Rabaçal* (plates 5th and 6th) was built from 1836 to 1851 and traverses the watershed by means of a tunnel called *das Levadinhas,* 440^{m},50 in length, 4^{m},40 in width by 4^{m},60 in height.

In a previous epoch, when the works were commenced, a tunnel had began to be dug for the same purpose through the Levadinhas hill, the works being carried to the length of 40 meters.

The *new levada of Rabaçal,* on a level inferior to that of the old one (plates 3rd, 4th, and 7th), was commenced in 1851 and is now finished, irrigating the parishes situated on the western side.

To surmount the difficulty offered by the watershed, another tunnel was made, 791 meters in length, whose openings for inflow and outflow are respectively reproduced in plates 3rd and 4th.

The tract of Rabaçal is one of the most picturesque of the island; its panorama represented in plate 2nd, and the cascades of Ribeira do Risco, plate 5th, suffice to prove it.

The waters of the principal springs rendered available in this region were collected at the source of «Ribeira da Janella», at a point where the rock forms a semicircular recess rising perpendicularly to the height of 130 meters and from which they flow in great abundance.

The works done in the open air and at mid height of the cliff were by far more difficult than those performed for the opening of the tunnels; the workmen at places let themselves down by means of ropes to depths of 200 meters and more, for the purpose of boring holes and blasting the rock, and, in order to avoid the dangers of the explosion, they darted and

swang by the ropes immediately after firing the mine, to find shelter at a convenient distance.

In the construction of the second group of water-courses there were three periods: the first in remote times, to which belong the two small conduits of Juncal and Furado [1], both coming, at last, to be State's property; the second, from 1840 to 1875, during which was built the second water-course of Furado, undertaken by a company, who were unable to finish the works; the third, from 1875 to the present time, during which the Government, taking the works to its charge, gave to them the greatest development.

This group of water-courses crosses also a much broken and diversified ground, and for this reason numerous and important constructive works had to be made, consisting mainly of bridges and tunnels.

Its whole length is divided into the following sections:

	Meters
Primitive water-courses	18:972
Camacha section	22:350
Fayal section	6:888
San-Jorge section	11:377
Total	59:587

These irrigation works, the roads, the bridges, of which plates 8th, 9th, and 10th show specimens, and the harbour works of Funchal, of which we give notice in the following article, show that the Portuguese Government has not neglected

[1] Furado — pierced, perforated. A term usually employed in the Island to indicate a tunnel.

the improvement of Madeira, and quite on the contrary has endeavoured to uphold in this last outlier of Europe and in the vicinity of the Canary Islands the credit of its administration.

THE FUNCHAL HARBOUR

(Porto do Funchal)

1 album (nos 25) with 5 photographic views: Quay and mole, finished — The same, beginning of construction, including the *Titan* — The same in course of construction — Mole between Pontinha and the Ilhéo rock, in course of construction, including the *Titan* — General view of the harbour after the close of the works.

The **island of Madeira**, as we have just seen, extends from east to west in a range of mountains, that on the northern side incline rapidly towards the sea and on the southern side expand, losing their asperity, and end in a slope by degrees more gentle.

On the southern border and foreground of the landscape, which unfolds itself over the mountain sides, is spread a broad bay, in whose deepest part, like the *cavea* of an amphitheater, lie **the port and the city of Funchal.**

To the west juts out the strip of land called «a Pontinha» (little point), and opposite, at about 200 meters distance rises from the open sea the *Ilhéo* rock, on whose platform above is established the semaphoric station, connected now by a telegraphic line with the postal telegraph office of Funchal.

The port is perfectly sheltered from the winds blowing from the north during almost the whole summer by the range of mountains disposed in the sense of the island's axis, so

much so that when the wind is stronger from this side, the sea in front of Funchal remains generally calm.

The winds, however, from the southern quarter are the most prevalent during winter, and on this account the idea has long since occurred of connecting the Pontinha with the Ilhéo rock by means of a mole, which, although not very extensive, would afford with the help of its natural termination or head a certain shelter against the south and southwest winds, being those that bring with them the greatest storms.

The port would remain, thus, only without shelter on the side of southeast, but luckly the storms from this quarter are of rare occurrence.

Such were the circumstances, which determined Government to order the elaboration of the plan for connecting the above mentioned rock with the island, and afterwards, the execution of the work, which was carried out by means of general undertaking in accordance with the contract sanctioned by the law of the 30th July, 1885.

The system adopted for the mole was, on a general rule, that of the French type, which had been rendered classic at Marseilles, and that in the continental part of the kingdom had just been employed with good result at Leixões harbour [1].

From the sea bottom at the depth of 8 or 10 meters up to low-tide mark is built the requisite basement of enrockment with assorted rubble stone of three classes, protected on the outside by artificial blocks of large dimensions and revested on the inside by an upright wall similarly composed of artificial blocks, but regularly coursed.

Above the level of low-tide the upright wall is crowned by a quay wall with the appropriate batter, available for the lar

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[1] See album nº 2 — Leixões Harbour.

gest vessels and supporting a pavement $5^{m},20$ in width; on the side looking seaward there is the sheltering wall, incased between the quay's terreplein and the artificial blocks revetment, raised to the height of 10 meters above low-water level and with the width of $5^{m},50$ at the top, a dimension which in the course of the works and by proposal of the contractors was reduced by taking 2 meters from the thickness of the wall.

The normal profile gives to the work an aggregate height of 20 meters, with exclusion of the foot-walk and the parapet on the outside edge of the sheltering wall, which have respectively $0^{m},60$ and $0^{m},90$ in height; the total width at the base is about 44 meters.

The mole is designed in straight alignement and in the direction from east to west.

The area sheltered is very limited, varying between 4 and 5 hectares.

The minimum depth of water is from 10 to 12 meters in the vicinity of the quay accessible to vessels, but it goes on decreasing till it dwindles down to nothing on the land side.

The maximum amplitude of the tides reaches 3 meters.

The material for the works was obtained on the sea side and at the distance of about 4 kilometers from the mole, from a scarped cliff constituted by columnar basalt, rising 25 meters above the sea level and resting on beds of worthless volcanic tuffs.

All the work of transporting the materials was done by sea.

The volume given to the artificial blocks was of 12 cubic meters, with the dimensions of $2^{m},0 \times 2^{m},0 \times 3^{m},0$; their weight is of 30 tons, because as the basalt, of which they are formed, is extremely heavy and compact, its density coming very near to 3 tons, and even the sand used in the composi-

tion of the mortars is basaltic and consequently of extraordinary weight.

The hoisting and putting in place of the blocks was effected by a 35-ton *Titan,* with the range of 22 meters, constructed according to the design of M. *T. Seyrig,* who had taken so distinguished a part in the elaboration of the projects of bridges Maria Pia and Luiz I over the Douro, opposite the city of Oporto [1].

This engine is represented at work in the plates 2nd and 4th, which have for special purpose to portray the construction of the mole.

These works, which were to commence within the term of a year counted from the date of the contract, that is, on the 9th of March, 1885, and be complet within the period of four years reckoned in the same way, were declared to be finished in the beginning of 1890.

On the 26th February, 1892, these harbour works experienced heavy damage.

The quay wall came down in a great part of its length, dragging after it the sheltering wall, which on the other hand, although shaken, with a flexion of nearly 5 meters and a deviation from the vertical line of above 2 meters, has remained standing up to the present, resisting as if it were a metallic girder.

The necessary repairs will commence soon.

The Funchal harbour works constituted a general undertaking for the total amount of 449:550$000 réis or nearly £ 100:000. The contractors were Messrs. *F. Combemale, Jules Michelon* and *A. Maury,* the two first general contractors for the 10th section of the Douro railway and the last engineer-

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[1] See albums ner 8 and ner 10 of the present collection.

in-chief for the construction of bridge Luiz I in behalf of the *Société de Willebroeck.*

The *Titan* was constructed in the workshops of Messrs. *Bon & Lustremant,* of Paris.

Engineer in charge of the works on the part of Government, sr. *J. B. Lopes de Andrade;* at present, sr. *J. H. Von Hafe.*

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